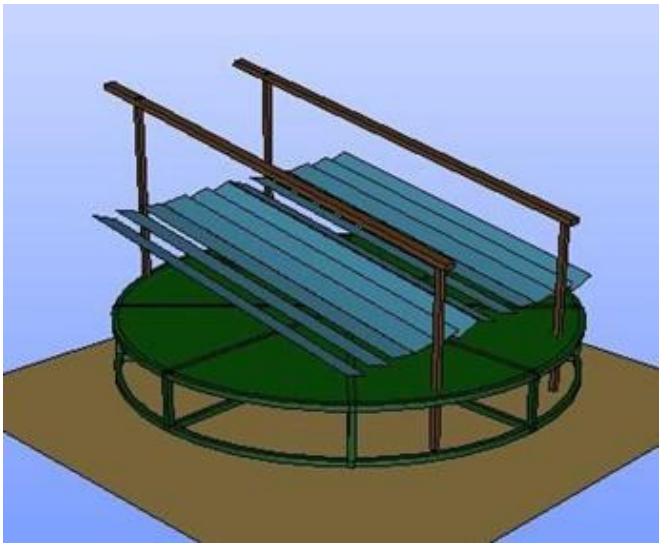
Preliminary design of Sundial for Mandrekas user-case

ASTEP project creates an innovative Solar Heat to Industrial Processes concept that will be tested at two industrial sites:

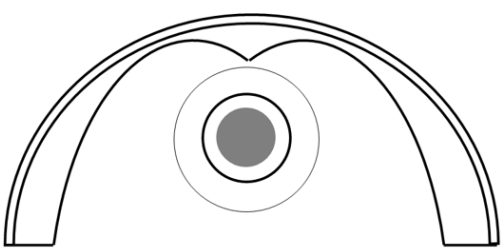
- a factory of ArcelorMittal Tubular Products located at a latitude of 47.1 N (Iasi, Romania);
- and the Greek dairy company Mandrekas (MAN), located at a latitude of 37.9 N (Corinth, Greece).

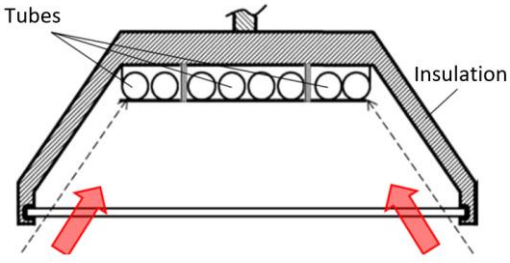
In the case of the MAN case, the requirement of the industry is a heating demand up to 175 °C for pasteurization of milk, and cooling for storing the products at temperatures around 5 °C. The foreseen production of thermal energy at daily and yearly basis are up to 135 kWh per day in summer and 25 MWh yearly.

The SunDial for this case-study is a rotary Linear Fresnel collector with a longitudinal mirror field arrangement, in such a way that the sun beam is always in the vertical plane defined by the receiver and.



In this study two types of receivers have been considered, namely single-tube and multi-tube, although the multi-tube one was discarded in a parallel study done for the ArcelorMittal end-user case, also in the scope of the project. In the case of single-tube receivers, two solar fields configurations have been analysed: single-field and two semi-fields.



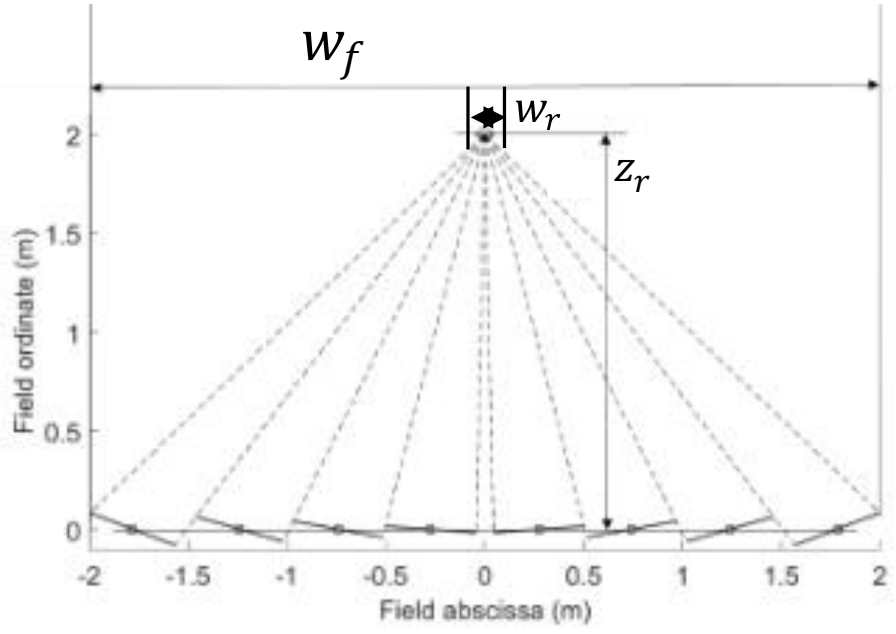


The system design specification implies the selection of a set of geometric parameters to define, namely (i) the receiver, (ii) the primary reflectors and the solar field configuration, and (iii) the selection of the heat transfer fluid. For facing the basic design, it is necessary to make use of numerical models to characterize the performance of the different elements of the Sundial, for instance, models required to estimate the thermal performance of both types of receivers, those developed to analyse the effect of the mirror dimensions on its optimal shape and the corresponding bending moment requirement, and those developed to analyse the optical performance of the field. All these analysis and models have been previously reported for the ArcelorMittal case-study.

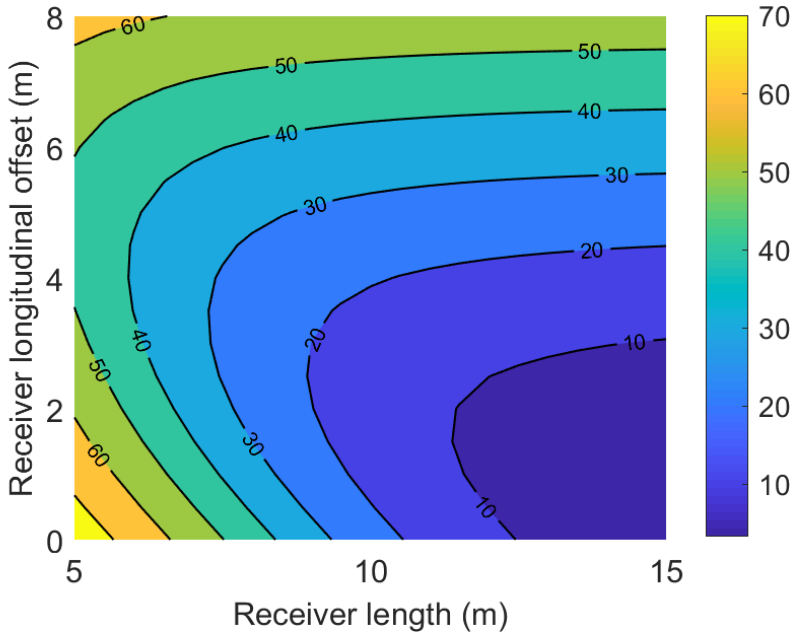
The single-tube design is restricted by the available commercial evacuated tubes, which have been extensively used integrated in Parabolic Trough Collectors and less extensively for Linear Fresnel Collectors. The external tube diameter is an important factor to be selected. It must be similar to the width where the concentrated irradiation is effective, so thermal and optic losses are minimum.

The multi-tube receiver consists of several tubes usually placed into a trapezoidal cavity. Although the single-tube receiver is the most widespread design for Fresnel collectors, there are also interesting cases using multi-tube ones.

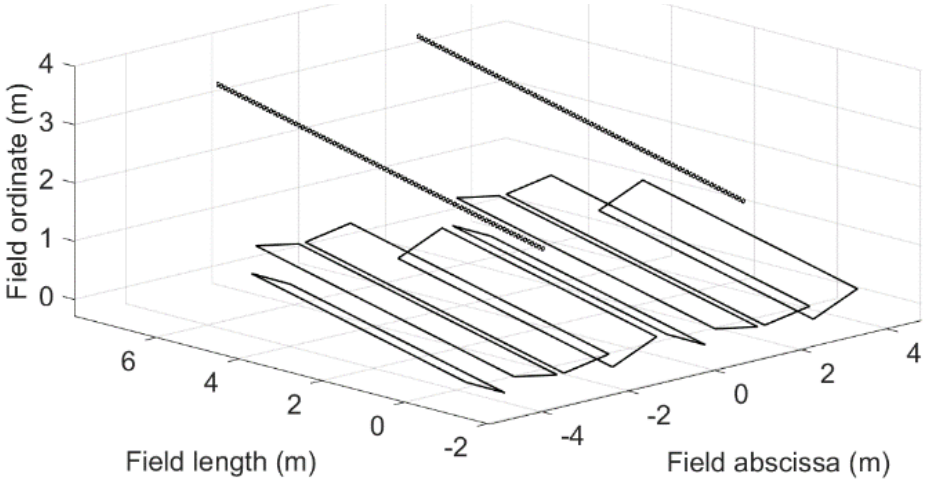
Regarding the mirrors' field, with the selected layout, the sun is always in the symmetry plane of the solar field and primary mirrors are fixed, and particularly located at its culmination for the transversal plane of the concentrator. Therefore, shading between mirrors is not an issue in the design of the field and only blocking should be considered to establish the distance between two neighbouring mirrors. As a result, the transversal location of mirrors should be such that the line that connects the right edge of any mirror with the receiver central point coincides with the line that connects the left edge of the neighbouring mirror at its right with the receiver.



The relatively short length of the SunDial collector compared to its width leads to important end-losses; that is to say, when the apparent sun altitude is low, the energy concentrated by the mirrors at its longitudinal end might be focused onto a line where there is no receiver. Therefore, the length of the receiver should be sufficiently high to partially avoid these losses and the offset for the location of the receiver over the mirrors field should be selected, as well as the tilt.



The multiple proposed configurations have been analysed following the described methodology, and then compared. The configuration finally selected for the Mandrekas industry includes two semi-fields of mirrors and single-tube receiver design.



Contributors:

R Abbas (UPM), R Barbero (UNED), MJ Montes (UNED), M Muñoz (UNED), A Rovira (UNED).