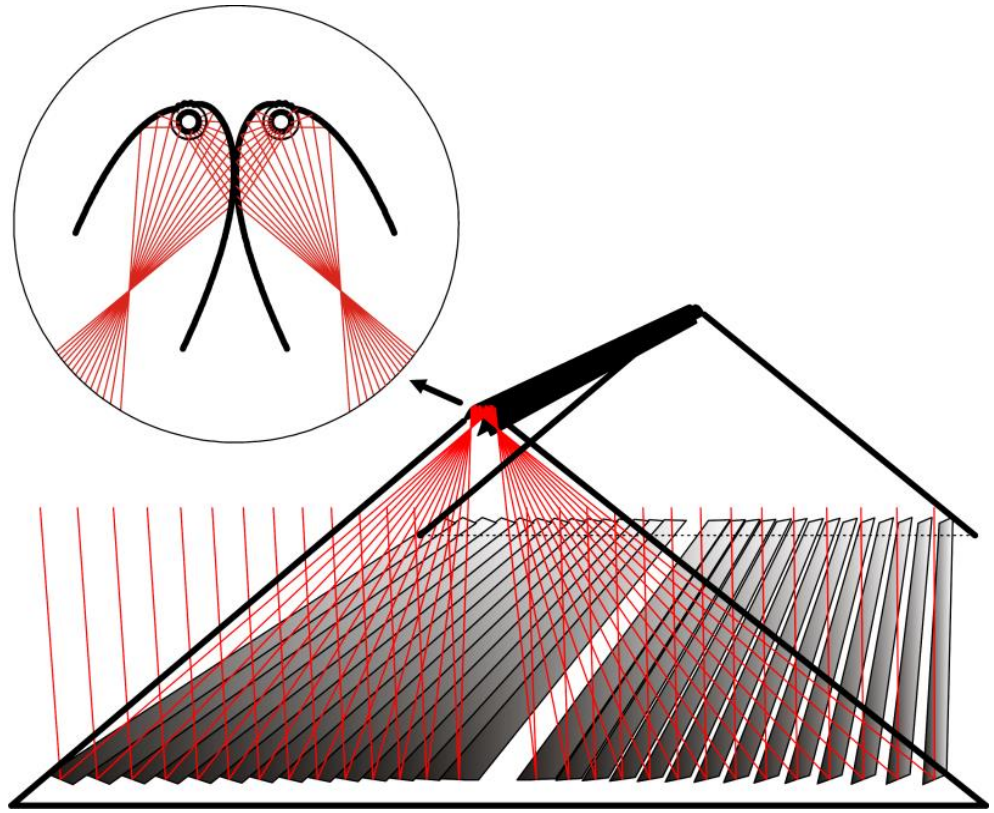
RENEWABLE ENERGIES CHAIR

UNIVERSITY OF ÉVORA



EMSP Symposium: ALFR-ALENTEJO. 20th October 2021

Presenter: Diogo Canavarro, UEVORA.

Project **ALFR-ALENTEJO**

Outline

- Overview
- Objectives
- Concept
- Expected performance
- Experimental demonstration
- Current status
- Main R&D achievements
- Upcoming activities and conclusions
- Acknowledgments
- References

Project **ALFR-ALENTEJO**

Overview

- **Full title:** Instalação, ensaio e análise de um concentrador Advanced Linear Fresnel Reflector para a produção de electricidade por via termosolar com armazenamento térmico
- **Consortium:** Univ. Évora [PT]
- **Duration:** 16.12.2019 – 15.12.2022 → **@M21**
- **Funding:** Alentejo 2020 (ALT20-03-0145-FEDER-039487)
- **UEVORA Eligible Cost:** 758,346.23 €
- **Website**: www.alfr-alentejo.uevora.pt

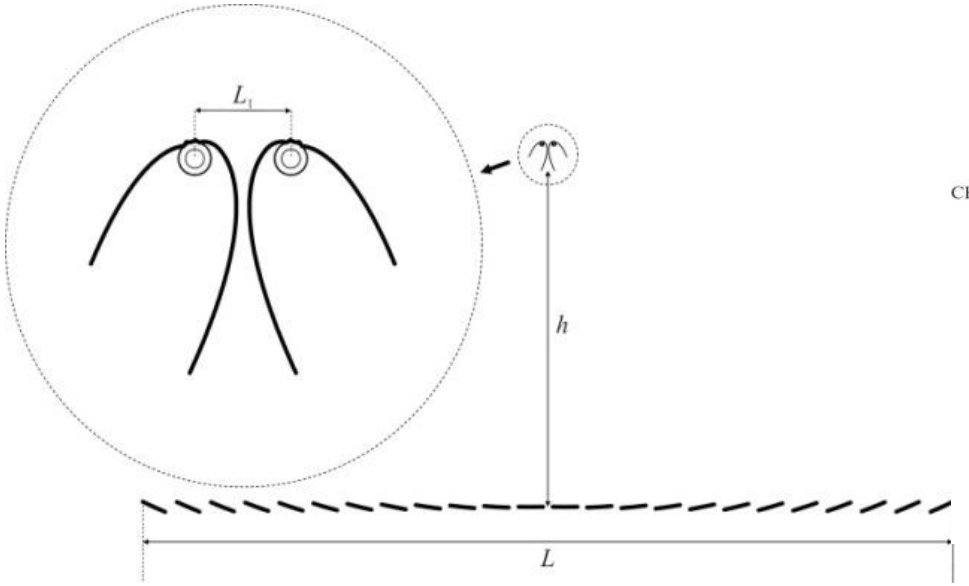
Project **ALFR-ALENTEJO**

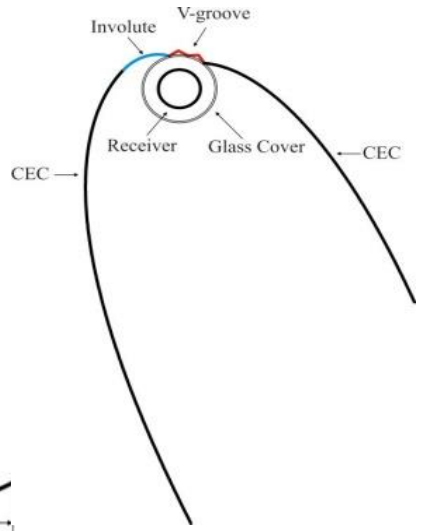
Objectives

- The present operation is aimed at the installation, testing and analysis of an **Advanced Reflective Linear Fresnel Reflector (ALFR)** prototype and will be carried out by the University of Évora within the research activities of the Renewable Energies Chair (REC).
- ALFR-Alentejo has two main goals: (1) **Achieve global solar-electricity conversion efficiencies above 14%** in the south of the Iberian Peninsula and (2) **To achieve a cost under 10€/kWh of LCOE**, under storage production, at the southern latitude of Portugal and respective solar radiation levels.
- The operation will be implemented using REC/INIESC's expertise, taking advantage of all research projects currently underway and their already established national and international partnerships.

Project **ALFR-ALENTEJO**

Concept



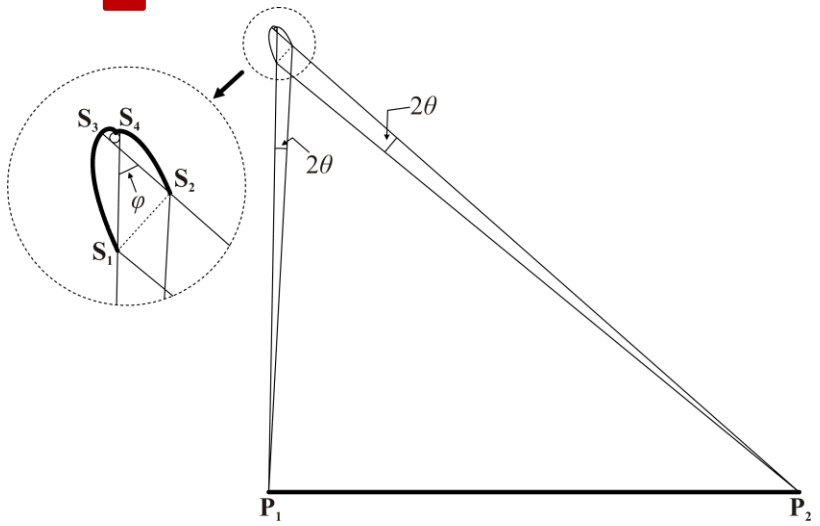


- ✓ **Compact concept** using two receivers placed in a single elevated structure;
- ✓ **Asymmetric** set of primary/secondary stage CEC combinations
- ✓ It uses a **very large primary** (*L*> 20m) contributing for the reduction of rows in the total field;
- ✓ The **two evacuated tubular receivers** can be fed by **a single pipe** and merge in a **single exit pipe**.

Project **ALFR-ALENTEJO**

Geometric details

Optic	Aperture width (m)	Total mirror aperture width (m)	Receiver radius (m)	Receiver height (m)	Number of mirrors	Mirror width (m)	Cg (X)	φ (°)
Dual Asymmetric CEC LFR Concentrator	26	22	0.035	10.8	22	1	45	49.73



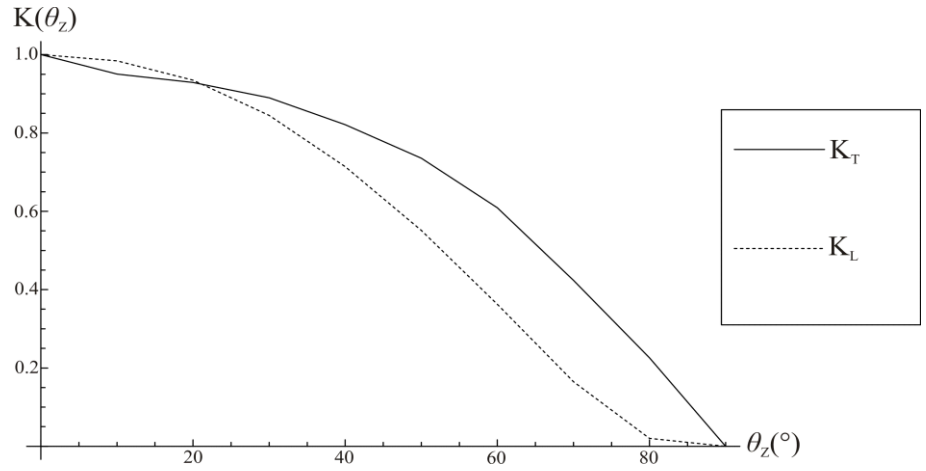
Note: Cg is the geometric concentration and ϕ the rim angle (see Figure).

Project **ALFR-ALENTEJO**

Raytracing calculations and expected performance

Optic	η_{opt0}	θ (°)	CAP
Dual Asymmetric CEC LFR Concentrator	0.7	0.75	0.59

Optical efficiency at normal incidence (η_{opt0}), half-acceptance angle (θ) and Concentration-Acceptance Product (CAP).

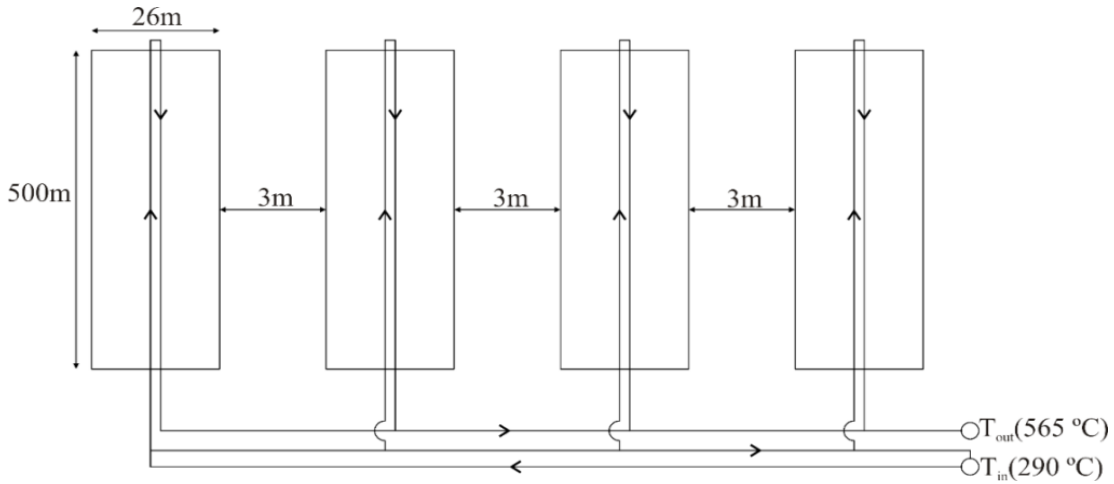


Incidence Angle Modifier ($K(\theta_Z)$) for transversal (K_T) and longitudinal (K_L) planes.

Project **ALFR-ALENTEJO**

Raytracing calculations and expected performance

- ✓ Thermal analysis using hourly DNI data for Évora (Portugal) and Hurghada (Egypt)



Plant configuration considered. The total number of rows is 23.

Assumptions:

- 250 000 m^2 of mirrors;
- T_{in} = 290 °C, T_{out} = 565 °C;
- Turbine efficiency = 0.42;
- Steam generation efficiency = 0.98;
- Intersect factor = 0.99;
- Inlet pipe length = 1100m, Outlet pipe length = 550m;
- Receiver losses at 565°C = 740W/m;
- Losses inlet pipe (290 °C) = 65W/m, losses outlet pipe (565 °C) = 130W/m
- DNI Faro = 2286 kWh/m^2/yr, DNI Hurghada = 3044 kWh/m^2/yr

Project **ALFR-ALENTEJO**

Raytracing calculations and expected performance

- ✓ Thermal analysis using hourly DNI data for Évora (Portugal) and Hurghada (Egypt)

Location	Thermal Energy delivered (kWh)	Electricity produced (kWh)	Total average yearly efficiency (kWh)
Évora, Portugal	1.94×10^8	7.96×10^7	0.140
Hurgahda, Egypt	3.02×10^8	1.22×10^8	0.163

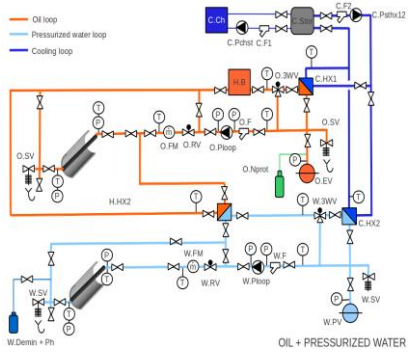
Project **ALFR-ALENTEJO**

Experimental demonstration

- **Testing of two ALFR collects on PECS and EMSP platforms**

EMSP

PECS



- **Goals:**
- Characterization of a 44m^2 collector on PECS platform using the ISO9806 norm. Thermal oil will be used as heat transfer fluid (HTF) up to temperatures of 380°C.
- Characterization of a 440m^2 collector on EMSP platform connect to a thermal thermocline storage system. Molten salts will be used as HTF and storage media up to temperatures of 560°C. Tests to be carried out: Vespertine Start-up/drainage; operations modes (start-up/dhut-down, non-solar profile, emergency and critical failure).
- Experimental validation, cost-analysis and eco-design strategies for future cost reduction and market penetration.

Project **ALFR-ALENTEJO**

Current status

- **Development of collectors by IDEA company (Italy)**




The current pandemic situation induced important delays on the implementation of the collector (impacts on works, material access/cost and shipping/delivering timings). An extension of the project is foreseen.

Project **ALFR-ALENTEJO**

Main R&D results

- **Scientific papers**
  → 3 so far [1-3]

- **Conferences**
  → CIES 2020 Conference [4]
  → EMSP Symposium

- **Reports**
  → 1 submitted last December 2020

Project **ALFR-ALENTEJO**

Upcoming activities and conclusions

- **Installation and operation of the two collectors**
  → Both collectors will be finally installed both on PECS and EMSP platform for future testing
- **Pandemic impact**
  → COVID-19 pandemic outbreak has been the major problem regarding the development of the project and its implementation. Measures to surpass these difficulties are already taking place (extension of contract).
- **Experimental results**
- → The activities to be carried out are essential for the validation of the concept and development of new strategies for further cost-reduction.

Project **ALFR-ALENTEJO**

Acknowledgments

- **Project supported by:**

ALENTEJO 2020

PORTUGAL 2020

UNIÃO EUROPEIA

Fundo Europeu de Desenvolvimento Regional

Project **ALFR-ALENTEJO**

References

- [1] Santos, A.V., Canavarro, D., Horta, P., Collares-Pereira, M., 2021. An analytical method for the optical analysis of Linear Fresnel Reflectors with a flat receiver. Solar Energy 227, 203–216. https://doi.org/10.1016/j.solener.2021.08.085.

- [2] Santos, A. V., Canavarro, D., Collares-Pereira, M., 2021. The gap angle as a design criterion to determine the position of linear Fresnel primary mirrors. Renewable Energy 163, 1397–1407. https://doi.org/10.1016/j.renene.2020.09.017.

- [3] Cavaleiro, S., Santos, A., Canavarro, D., Malico, I., Janeiro, F., 2021. Optimization of Linear Fresnel Reflector Solar Collectors Using a Genetic Algorithm. SYMCOMP 2021 Conference 25–26.

- [4] Canavarro, D... [et.al.] - ALFR-Alentejo: demonstração experimental de um prótipo advanced linear Fresnel reflector em Évora. In: CIES2020: As Energias Renováveis na Transição Energética: Livro de Comunicações do XVII Congresso Ibérico e XIII Congresso Ibero-americano de Energia Solar. Helder Gonçalves, Manuel Romero (Ed.). Lisboa, Portugal: LNEG, 3-5 Novembro, 2020, p. 177-183 10.34637/cies2020.1.2018

UNIVERSITY OF ÉVORA

RENEWABLE ENERGIES CHAIR

CONTACT US!

catedraer@uevora.pt

www.catedraer.uevora.pt

Évora, Portugal