# LINEAR FRESNEL SOLAR COLLECTOR CONCENTRATOR – A REVIEW

**Patricia Scalco[1]**
**Jacqueline Biancon Copetti[2]**
**Mario Henrique Macagnan[3]**

Unisinos - Universidade do Vale do Rio dos Sinos
Mechanical Engineering Graduate Program - Renewable Energy Sources Laboratory
Unisinos Avenue, 950, São Leopoldo, 93022-750, RS, Brazil
[1] patrscalco@edu.unisinos.br
[2] jcopetti@unisinos.br
[3] mhmac@unisinos.br

**Jeferson Diehl de Oliveira**
FSG-University Center, Center of Innovation and Technology, Department of Mechanical Engineering
Os Dezoito do Forte, 2366, Caxias do Sul, 95020-472, RS, Brazil
jeferson.oliveira@fsg.edu.br

**Abstract.** *Concentrated solar power is one of the most promising and competitive ways to generate energy by using incident solar irradiation. Among the existing technologies, Linear Fresnel Concentrator (LFC) uses the principle of solar concentration for producing useful heat in medium and high temperature applications (>150 °C). The LFC system, when compared with other solar concentration technologies, presents a satisfactory thermal and optical performance and low-cost. Besides that, the LFC system appears as a viable solution due to its simple and flat structure and easy maintenance. However, it is still necessary to investigate and understand the progress of research in this area to improve the performance of the LFC. Thus, this study aims to present a review of the current state of development of this system and related research, as well as the projects implemented. Moreover, this work presents the research and projects in Brazil, where this technology is not so consolidated yet and needs to be further explored, both in experimental and theoretical studies, since the country is located geographically in an area with high Direct Normal Irradiation (DNI). For this review, some of the main characteristics of LFC systems are considered, such as the mirror field, type of the receiver and absorber, and the heat transfer fluid used in each case. The orientation and the performance of the LFC system, and an evaluation of characteristics from operational LFC power plants are also presented. From the survey of the current state of art, a discussion of LFC systems to build an approach from the scenario of this technology is made and the findings are summarized. Finally, the current trends and the future challenges in the research and development of LFC technology are highlighted.*

*Keywords: Concentrated solar power; linear Fresnel concentrator; critical review.*

## 1. INTRODUCTION

Global energy consumption is constantly increasing due to the growth of population and industrial activity. Moreover, most of the produced energy comes from non-renewable sources. The exploration of these energy sources is associated with the degradation of the environment and contributes to the worsening of global warming. These concerns have forced studies and research of technologies that use clean and renewable energy. Thus, the use of solar radiation is one promising alternative, considering its potential and lower production costs. Among the existing technologies that use solar radiation to producing electricity and thermal power, concentrating solar power (CSP) has the potential to provide a considerable part of the future demand for renewable energy, with a contribution of 7% by the year 2030 and 25% by the year 2050 (Islam *et al.*, 2018).

CSP systems use reflexive surfaces to concentrate the solar radiation and reflect it to a receiver element to use this radiation more effectively. In the receiver, a heat transfer fluid (HTF) flows and absorbs the thermal energy. These systems allow the receiver to reach medium and high temperatures (> 400 °C) due to its smaller surface area, which considerably reduces heat loss to the environment (Sá *et al.*, 2018). Furthermore, it is noteworthy that, in CSP systems, diffuse radiation cannot be harnessed, since it is not possible to concentrate it, and only the Direct Normal Irradiation (DNI) can be used. The main technologies that use the principle of CSP are solar dish, solar tower, parabolic trough collector, and linear Fresnel collector (LFC), which is the object of study in this work.

LFC systems have a line-focus concentration and are composed of a mirror field, a solar tracking system, and a receiver element, according to Figure 1. The solar radiation reaches the mirror field, which reflects it to the receiver. The mirror field is composed of arrays of mirrors that follow the sun path throughout the day. The movement of the mirrors

happens through the solar track system, which, in general, uses stepper motors. The receiver element has one or more absorber tubes and a receiver cavity, which have its internal walls painted in black. The receiver cavity can be projected in different geometries, depending on the application and the needed demand. The most used geometry is trapezoidal. In cases where the receiver cavity has its inner walls composed of a reflexive material, it is called secondary concentrator, and, commonly, more complex geometries are used – like the CPC (Compound Parabolic Concentrator).
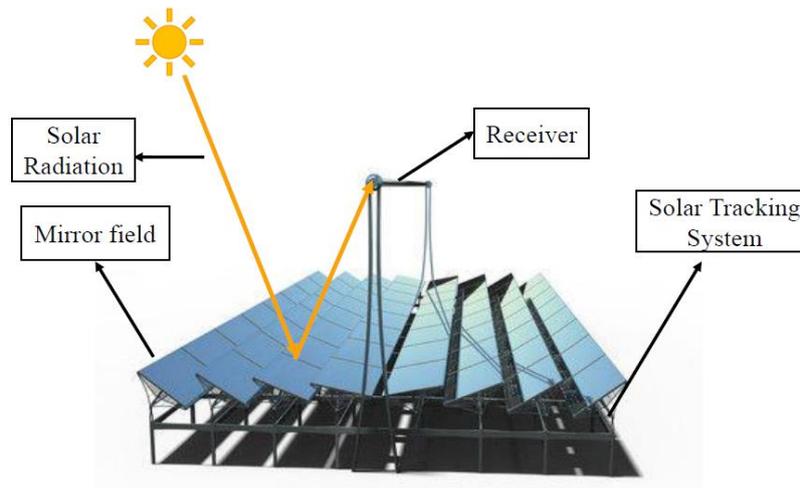


Figure 1. Linear Fresnel Reflector system representation.
Source: Adapted by SciWhaleDesign – LFR technology 3D illustration (2021)

Among the existing CSP technologies, LFC is not the one that has the best performance, but its advantages are in its flat structure, which turns maintenance easier and has a low-cost construction. Also, differently from other CSP technologies, in LFC systems, only mirrors move, and the receiver remains fixed. Moreover, another advantage, as the mirrors are flat or slightly curved, the wind loads are lower than in systems that use curved reflectors. The capacity of LFC power plants varies from 10 to 200 MW, and the yearly efficiency is estimated between 8-10 % (Islam *et al.*, 2018).

The good performance and cost-benefit are attracting investment, and its development and research are advancing (Mihoub, 2020). Thus, this study aims to review the current state of art of LFC systems and analyze the existing designs and applications. The research and the pilot projects in Brazil are also presented, where the CSP technology is not consolidated yet and needs to be further explored since the incident DNI in this country presents satisfactory levels for the installation and operation of these power plants. Moreover, this analysis considers different aspects of LFC systems and their performance, such as the mirror field, the receiver geometry, the absorber tube characteristics, and the thermal fluids. Finally, the future steps in LFC technology are highlighted.

## 2. OVERVIEW OF LFC TECHNOLOGY

The LFC concept of power generation has been extensively analyzed in many different aspects, and there are numerous types of prototype designs. In this study, an analysis technique was employed to approach the literature review of LFC technology under the scope of the solar and renewable energy field. At first, the Scopus bibliographic database was selected to extract information about LFC publications. The following search terms were used to collect the maximum number of papers on LFC studies: "linear Fresnel reflector" OR "linear Fresnel concentrator" OR "linear Fresnel collector". The information was collected considering the keywords present on the title, abstract or, keyword of the publication. By this process, a total of 571 research articles on LFC technology published from 1980 to April 2021 were collected. Figure 2 presents the distribution of publications over the years. The growth of publications on LFC studies in the last decade (2010 – 2019) consists of 77,58 % of all research papers in this field.

Among the countries that contribute to the state of art of LFC literature, those that have more publications are India, China, Spain, Italy, Germany, and United States, as can be noted in Figure 3. These countries together represent more than 50 % of the total amount of publications.
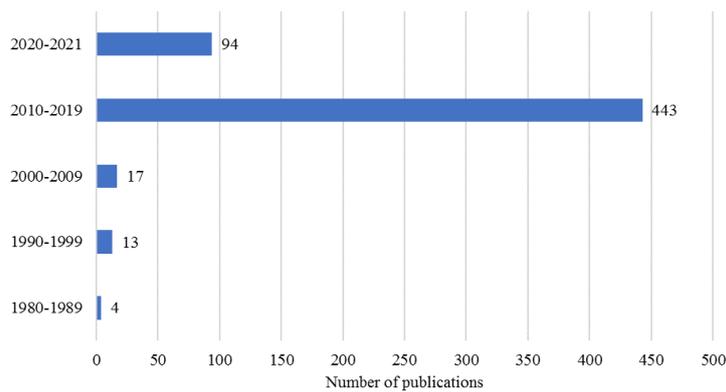
Figure 2. Number of LFC related publications on Scopus bibliographic
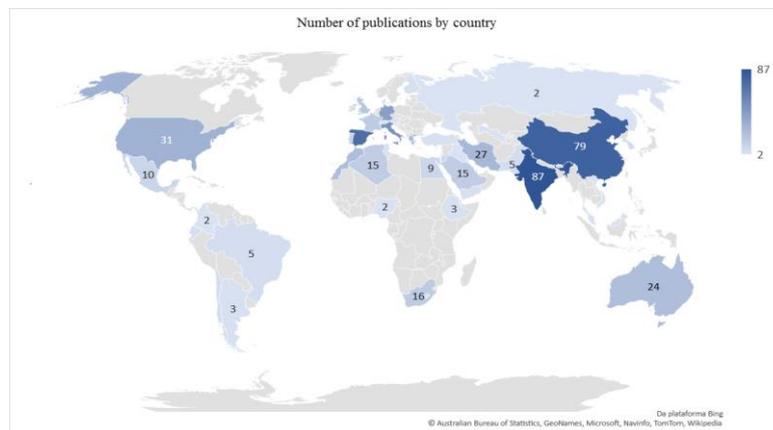database over the decades (1980 – April 2021).



Figure 3. Number of LFC related publications by country on Scopus bibliographic
database over the decades (1980 – April 2021).

## 2.1 Optical behavior of the system

The optical behavior of solar concentrators can be analyzed using a ray-tracing method that, if well applied, allows the previous identification and evaluation of project limitations, such as shading and blocking between adjacent mirrors, end-line losses, shading by the absorber structure on the mirror field, cosine effect, and losses by the gaps between adjacent mirrors (Figure 4). In LFC systems, each line of mirrors is moved in such a way that its inclination allows the reflection of the direct irradiance in the absorber. However, the mirrors suffer from shading and blocking from neighboring mirrors. Shading of a mirror is blockage of incoming sun rays reaching the mirror by its neighbor(s) (Fig. 4a), and blocking is blockage of reflected sun rays reaching the receiver assembly by its neighbor(s) mirror(s) (Fig. 4b).

The Sun presents a variation in elevation considering its apparent path. Therefore, the mirrors move in a transversal direction (East-West) to compensate the apparent movement of the Sun on this axis. However, this movement also occurs in the longitudinal direction (North-South), in which there is no movement of the mirrors or the absorber. Thus, some reflected rays do not reach the absorber. This effect is called end-line losses, and Figure 4c represents it. Besides this, another relevant limitation of the system is the shading caused by the absorber element on the mirror field (Figure 4d). The cosine effect is caused since the apparent area of the mirrors varies with the angle of incidence between the Sun ray and the normal of the surface (Figure 4e). In addition, part of the incident radiation is lost in the gap between the mirrors and does not reach the absorber (Figure 4f).

Sharma *et al.* (2015) presented an analysis of the thermal losses as a function of the aforementioned project limitations, geometric, and geographic characteristics. They found that the annual losses due to the cosine effect are higher for LFC systems geographically positioned in East-West orientation. In addition, systems installed at high latitudes have greater losses due to shading when compared to places with lower latitudes. The end-line losses also significantly influence the LFC performance on high latitudes: the reflected rays from the mirror field do not reach de receiver, making it inactive for heat transfer purposes (Hongn *et al.*, 2015).
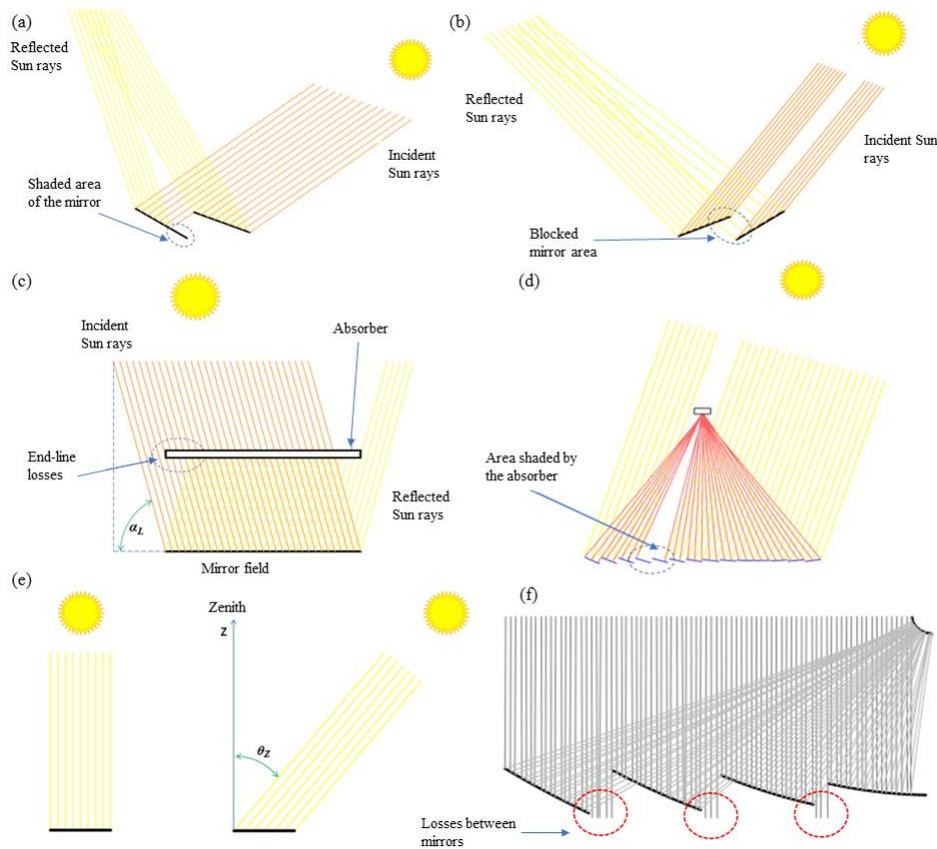
Figure 4. Representation of losses due to (a) shading and (b) blocking between adjacent mirrors; (c) end-line losses and (d) shading by the absorber structure; (e) cosine effect, and (f) losses between mirrors.
Source: Adapted from Webler *et al.* (2019) and Mertins (2009)

Webler *et al.* (2019) proposed a study of the impact of LFC parameters on geometric performance. It is known that geometric characteristics influence on optical limitations. Figure 5 shows the geometrical losses considering the aforementioned project limitations and the spacing between adjacent mirrors. As the losses due to the cosine effect increase, so does the spacing between the mirrors. It happens because, with the increment of the spacing between mirrors, the width of the mirrors is reduced, resulting in more rows of mirrors. This is offset by the reduction in the losses by shading. The limitation with the greater impact on the losses is the gap between mirrors, which was approximately 0.2 % for 0 mm of spacing, and increases to 5.2 % for 40 mm of spacing.
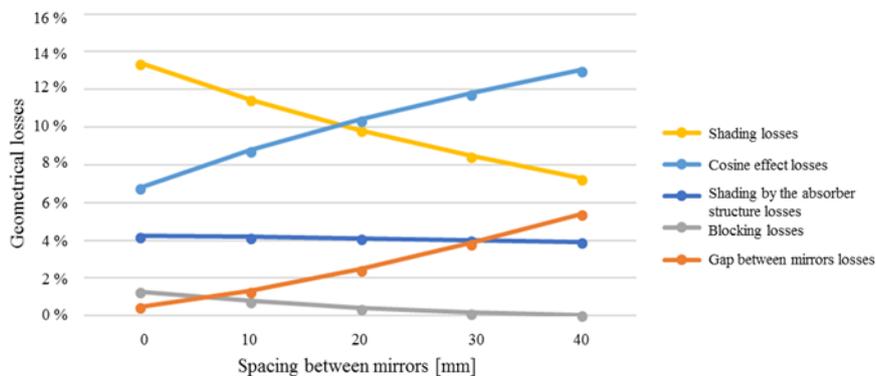


Figure 5. Geometrical losses as a function of the spacing between mirrors considering each project limitation.
Source: Webler *et al.* (2019)

Besides the project limitations, solar tracking errors also can negatively influence the performance of the LFC system, directly impacting the energy loss. In this context, Barbón *et al.* (2020) explored the effect on the absorbed power of solar tracking errors. The main findings are that the errors due to the solar tracking system have a non-linear direct influence on the power losses: the larger the error, the larger the absorbed power loss, therefore small solar tracking errors

are acceptable. Regarding mirror influence, the power absorbed is lower for the mirrors located near the borders of the mirror field (Figure 6). Moreover, the authors found that a receiver without a cavity (or a secondary concentrator) requires a much more accurate solar tracking system, once an error that could be acceptable with a cavity become unacceptable without it.
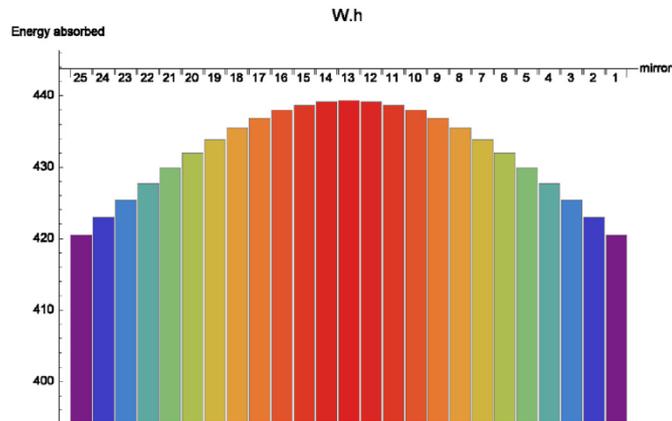


Figure 6. Absorbed power (June 21st) in each mirror of the LFC system.
Source: Barbón *et al.* (2020)

## 2.2 Receiver and heat transfer fluids

The study and improvement of design and analysis of linear Fresnel concentrators are beyond geometric analysis. The receiver, for example, can be analyzed as a separate element from the rest of the system, and it comprises a cavity receiver with or without a secondary concentrator. The cavity receiver has inner walls painted in black or with selective ink that improves the absorptivity of solar radiation. For the case of black ink, the emissivity is also high, so with selective ink, this emissivity can be reduced between 0.2 and 0.4, then reducing the thermal losses. Moreover, it is composed of more than one absorber tube. Otherwise, the secondary concentrator has its inner walls composed of reflective material to maximize the optical effects inside the absorber. Usually, the secondary concentrator has one absorber tube, and it can be evacuated or not.

Besides that, the use of a glass plate in the basis of the receiver has several advantages, as explored by Beltagy (2021), that studied its influence on optical performance. For this, the author proposed a numerical simulation based on Monte Carlo Ray Tracing (MCRT), and the receiver analyzed is composed of an absorber tube, secondary concentrator, and a glass plate. The geometry used in the secondary concentrator is the CPC. The results present advantages and disadvantages of the use of glass plate: the advantage is that it improves the receiver thermal performance, creating a greenhouse effect, limiting thermal losses by convection, and protecting the interior of the receiver against wind and other climatic conditions; although, when the receiver has not a glass plate, the optical performance is increased by 5.6 %/year.

Abbas *et al.* (2018) presented an analysis of different designs for secondary concentrators: the CPC (Figure 7a); the adaptive design concentrator (proposed by NREL – National Renewable Energy Laboratory; Zhu (2017)) (Figure 7b), which uses a method of distribution of points in a line perpendicular to the normal; and the segmented parabolic secondary concentrator (SPSC) (Figure 7c). The analysis was carried out using the MCRT method, in which it was considered three optical properties: annual optical efficiency, mean flux intensity, and circumferential flux intensity homogeneity. From this, the authors concluded that the SPSC does not seem competitive compared to the other designs: when the mean flux intensity is 20 kW/m² the efficiency of the receiver SPSC is 45 %, while for the CPC and the adaptative design the performance is similar (~50 %). When the CPC is compared with the adaptive design concentrator, small differences are found: the last seems to achieve higher efficiency for mean flux intensity up to 20 kW/m², and for 25 kW/m² when an evacuated tube is used. For higher flux intensities, the CPC achieves higher efficiencies.

The characteristics of the absorber tube also can be explored considering that is where the HTF flows, and the radiation is effectively converted into heat. Each application of the system has an optimal configuration that supplies the demand. Therefore, it is important to understand the possible configurations, and some hybrid designs, as proposed by Montes *et al.* (2017). They compared the performance and the heat loss for three single-tube layouts: evacuated, non-evacuated, and non-evacuated with a glass plate at the aperture of the receiver. The geometry used was the CPC, and the HTF is molten salt. The heat loss was quantified for each condition considering three parameters: the temperature difference between the tube wall and the environment, incident concentrated flux on the tube, and wind velocity. The evacuated tube has the lower heat loss, followed by the glass plate and the non-evacuated. However, this behavior does not repeat when the HTF working temperature is considered: the evacuated tube presents a lower working temperature when compared to the other designs. This result and the fact that the non-evacuated tube design implies a lower cost than the others suggested possible advantages in hybrid systems including non-evacuated receivers together with those that have a higher thermal performance.
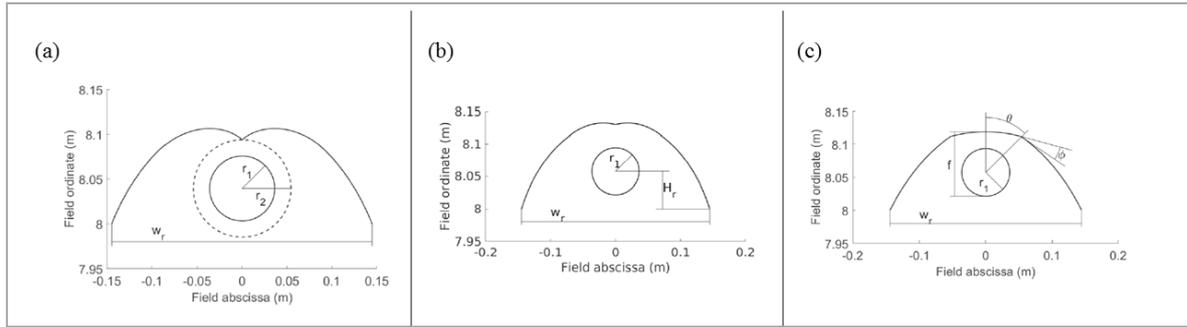
Figure 7. Design of secondary concentrator: (a) Compound Parabolic Concentrator (CPC); (b) Adaptative design; (c) segmented parabolic secondary concentrator.
Source: Abbas *et al.* (2018)

Qiu *et al.* (2016) developed a numerical model by coupling MCRT and Finite Volume Method (FVM) to simulate the energy conversion process in the LFC with a trapezoidal cavity receiver, eight absorber tubes, and water as Heat Exchange Fluid (HTF). The model proved to be feasible and reliable for the simulation of the heat exchange. They observed that, under typical conditions, the solar flux on the trapezoidal cavity can be higher than 47.6 kW/m². Moreover, the annual optical efficiency between 44.7-60.1 % from the equator to N50°can be achieved by the system. The study of the thermal performance demonstrates the collector efficiency is 48.3%-72.0% with an HTF temperature range between 550 - 773 K and DNI range between 400-994.5 W/m². The authors concluded from the analysis of the heat transfer that the losses by radiation contribute about 81 % to 87% of the total heat losses in the absorber tubes under typical conditions.

Dabiri *et al.* (2018) also analyzed an LFC receiver system and evaluated heat transfer rates and thermal losses. The receiver analyzed is composed of a trapezoidal cavity, six absorber tubes made of copper, and a glass plate closure. They evaluated the effect of the cavity angle and the absorber tube size. The model was analyzed through numerical analysis, and it was found that when increasing the size of the absorber tube, the heat transfer increases as well (Figure 8a), the same happens with the angle of the trapezoidal receiver walls (Figure 8b). Furthermore, the authors observed that 85.2– 91.3% of the total heat transfer rate occurs by radiation. Besides this, as tube sizes increase, heat loss to the glass cover and wall insulation increases by about 31.9 %.
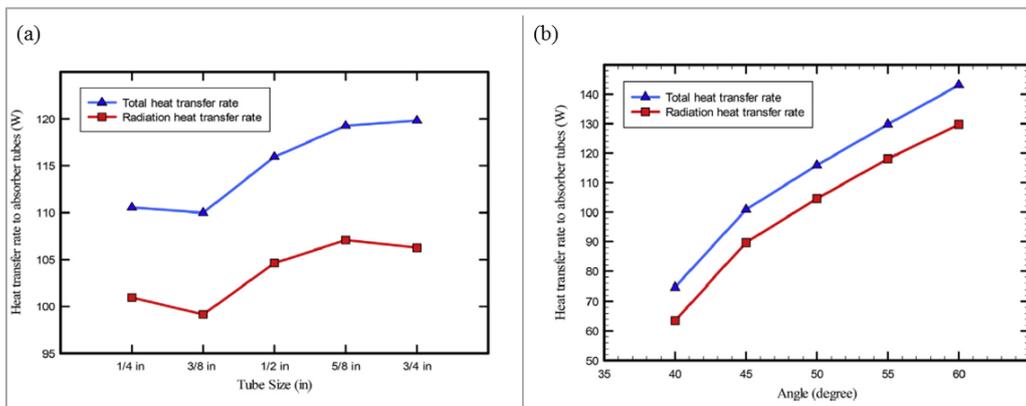


Figure 8. Heat transfer rate to absorber tuber for (a) different angles, and (b) different tube size.
Source: Dabiri *et al.* (2018)

Mohan *et al.* (2018) performed the analysis of heat transfer losses from a trapezoidal cavity receiver in an LFC system using a radiation-conduction model. Several studies showed that the convective losses represent up to 15 % of the total heat losses, otherwise the velocities are disregarded due to stratification of isotherms with hot air trapped on top of the cavity, which suggests that convection should be negligible. Thus, the authors hypothesized that what is considered convective is conduction through (almost) static air inside the cavity. The authors compared the obtained results from numerical simulation with the radiation-convection model and observed that the difference is minimal – less than 1% – as had already been studied by Saxena *et al*. (2016).

Scalco (2016) and Scalco *et. al* (2020) presented a thermal analysis of losses and efficiency of a single-tube receiver with a CPC secondary concentrator surface and a glass plate. The authors developed a thermal balance considering each component of the receiver in the heat exchange. The analysis considered the emitted radiation and the view factors of each surface. The heat exchange fluid used in the simulation is Therminol VP-1. The authors observed that the thermal losses increase, as emissivity increases, since the heat transfer by radiation is higher. Moreover, they verified that for smaller lengths of the tube, mass flow rate has not a significant impact, but for smaller mass flow, as the length of the

tube increases, increase as well the thermal losses. Finally, the findings revealed a performance of the system under different conditions around 80 % for a DNI of 1000 W/m² and 65 % for 400 W/m².

Several studies address the different HTFs used in LFC systems, as summarized in Table 1. Fluid selection depends on the application, thermodynamic cycle, type of storage, energy conversion technologies, among others.

Synthetic oils are used for a long time and are an option commercially consolidated, even its limitations, such as thermal instability and inflammability risks. Compared to synthetic oil, molten salt enables a greater output temperature, increasing the thermodynamic cycle efficiency. However, its solidification at low temperature and corrosion is a challenge. The direct Steam generation has a low-cost investment, and the high working temperature is attractive, even with thermal stress due to two-phase flow. The nanofluids have the advantage to provide the best thermal conductivity, but the challenge is the dispersion issue and the high cost. Furthermore, other HTFs are proposed, such as liquid metal, like the liquid sodium, which has high thermal conductivity and enables the LFC system to operate under high temperatures, but the high risks of the operation are many and limit the applications.

Table 1. Characteristics of different HTFs summarized.

| Working Fluid | Temperature range (°C) | Advantages | Disadvantages | References |
|---|---|---|---|---|
| Synthetic oil | 293–390 | Commercially mature. | Temperature limit. Thermal instability. High cost. Inflammability risk. | Collares-Pereira (2017) Khandelwal *et al.* (2021) Rajendran *et al.* (2019) |
| Water (DSG – Direct Steam Generation) | 245-500 | Save of heat-exchangers. High temperature. Low cost. Environmentally friendly. | Thermal stress due to two-phase flow. Difficult flow control. High pressure. | Ghodbane *et al.* (2019) Collares-Pereira (2017) Rajendran *et al.* (2019) |
| Molten Salt | 350-560 | High temperature. Thermal storage medium. Relatively inexpensive. Thermodynamic cycle efficiency. | Solidification at low temperature. Metal corrosion. High maintenance requirements at winter. | Bellos *et al.* (2018) Bachelier and Jäger (2019) Collares-Pereira (2017) Rajendran *et al.* (2019) Sun *et al.* (2020) |
| Nanofluids/Nanoparticle (Al2O3, SiO2, CuO, Au, etc.) Base fluid (Synthetic oil, water, etc.) | - | Heat transfer coefficient. | More pumping work. High cost. Dispersion issue not well developed. | Bellos and Tzivanidis (2018) Sun (2021) Rajendran *et al.* (2019) |
| Liquid Sodium | 90-880 | High temperature. High Thermal Conductivity. Fast start-up procedures. Quick response of the control. | Risks of operation. | Bellos *et al.* (2018) Bachelier and Jäger (2019) Rajendran *et al.* (2019) |

The studies presented above show how the development of research using LFC technology is wide and can be approached from different points of view and for different conditions. In the next section, an approach of the LFC operating power plants will be presented.

## 3. LFC OPERATIONAL POWER PLANTS

The use of LFC for power and electricity generation has been used in many places all over the world. Nowadays, according to NREL (National Renewable Energy Laboratory) (SolarPACES, 2021), there are six LFC power plants in operation. Table 2 shows the current operational power plants. Beyond these, there other power plants that are under development or construction and will be in operation soon.

The capacities of the LFC power plants vary from 10 to 200 MW, and the yearly efficiency is estimated to be 8 – 10%. The largest operational LFC power plant is installed in India with a capacity of 125 MW and electricity generation by year of 280,000 MWh/y. Besides this, Rende-CSP Plant was built for demonstration, while Puerto Errado 1 Thermosolar Power Plant (PE1) and Puerto Errado 2 Thermosolar Power Plant (PE2) were built for commercial production in 2009 and 2012, respectively. In China, besides the Dacheng Dunhuang 50 MW Molten Salt Fresnel project, there are other four CSP power plants under construction, whose capacity will be 50 MW (SolarPACES, 2021). Furthermore, it is possible to verify that power that uses molten salt (Dacheng Dunhuang 50 MW Molten Salt Fresnel project and Dhursar) reaches outlet temperatures higher than water, synthetic oil, or other HTF.

Table 2. LFC current operational power plants over the world. Source: SolarPACES, 2021.

| Project Name | Location | Electricity Generation (MWh/year) | Start Production Date | Solar-Field Average Outlet Temperature | Heat-Transfer Fluid | Turbine Capacity | | Storage type | Area (hectare) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Turbine Capacity (Gross) | Turbine Capacity (Net) | | |
| Puerto Errado 1 Thermosolar Power Plant (PE1) | Spain | 2,000 | 2009 | 270 °C | Water | 1.4 MW | 1.4 MW | Single-tank thermocline | 5 ha |
| Puerto Errado 2 Thermosolar Power Plant (PE2) | Spain | 49,000 | 2012 | 270 °C | Water | 30 MW | 30 MW | Single-tank thermocline | 70 ha |
| Dhursar | India | 280,000 | 2014 | | Water/Steam | 125 MW | 125 MW | None | 340 ha |
| Rende-CSP Plant | Italy | 3,000 | 2014 | 280 °C | Diathermic oil | 1 MW | 1 MW | None | 2 ha |
| Dacheng Dunhuang 50MW Molten Salt Fresnel project | China | 214,000 | 2019 | 535 °C | Molten Salt | 50 MW | 50 MW | 2-tank direct | 318.6 ha |
| eLLO Solar Thermal Project (Llo) | France | 20,200 | 2019 | 285 °C | Water | 9 MW | 9 MW | Other | 35 ha |

## 4. OVERVIEW OF LFC TECHNOLOGY IN BRAZIL

Brazil is geographically positioned in an area with high DNI. The best locations for installing CSP plants in Brazil are in the northeastern semi-arid (Martins *et al.*, 2012), where the annual solar irradiation reaches 2.2 MWh/m² and the average daily irradiation is higher than 5.0 kWh/m². In addition, this region has a low terrain slope and is interconnected to the Brazilian electricity distribution grid. These characteristics contribute to the viability of CSP projects in this region.

In Brazil, there are not CSP plants installed yet, and only in 2013 the theme got attention and became authorized to participate in energy public sales (Tolmasquin, 2016). According to Pigozzo (2019), in 2015 ANEEL (National Electric Energy Agency) launched the Call for Strategic P&D Project 19/2015 "Development of national technology for heliothermic electricity generation", in which more than seventy national companies showed interest in developing projects in heliothermic energy. Furthermore, there is an incentive from research funding agencies, such as CNPq, that have already opened specific calls for academic research on the topic.

Sá (2018) and Pigozzo (2019) presented the development and analysis of a small-scale linear Fresnel concentrator for steam generation. The experimental power plant – located in the Federal University of Santa Catarina – has 60 m² and can reach temperatures up to 230 °C. The absorber has a trapezoidal cavity and a multitube system (six absorber tubes). Sá (2018) presented a parametrical and thermal analysis based on experimental results. Moreover, the author developed a pressure drop model for single-phase and two-phase flow and validated it in the experimental power plant. Pigozzo (2019) analyzed the heat transfer in the absorber through a theoretical model and validated it in the experimental power plant. An analysis of the influence of the glass plate on the system performance was carried out: without the glass plate, the system had higher initial efficiency, and consequently, higher thermal losses. Besides, for each DNI there is a temperature value in which the use of a glass plate becomes advantageous – for 1000 W/m² is 92 °C, and for 400 W/m² is 50 °C. An innovation developed for this workbench was the system for longitudinal movement of the absorber, which minimizes the end-line losses.

At Unisinos University, located in the state of Rio Grande do Sul, also is developed research about linear Fresnel collectors and an experimental plant (Macagnan *et al.*, 2014, Moreira, 2019). The developed concentrator also uses the receiver element with a trapezoidal cavity with four absorber tubes. The concentrator has a total area of 25.2 m² and the solar field is composed of 14 rows of mirrors and the receiver is positioned at 3 m in height. A solar tracking system was developed using step motors (Oliveira *et al.*, 2018). The thermal fluid is a synthetic oil (Paratherm HE), and the preliminary results indicate an efficiency of around 28 %, and temperature variation between the inlet and outlet of the absorber tube varied 9.1-9.7 °C. This efficiency is lower than other LFC power plants, even on a small scale. One factor that influences that reduces the efficiency is the type of ink used on the inner walls of the receiver – a selective Nickel ink, for example, can contribute to achieving an efficiency close to or above 40% (which is expected for LFC systems).

Other authors in Brazil developed studies about concentrated solar power, such as Burin *et al.* (2017) that evaluated the integration of CSP with a sugarcane bagasse cogeneration plant located in Campo Grande (Brazil). The plant is equipped with two 170 t/h capacity steam generators that provide steam at 67 bar/525 °C. They evaluated three possibilities of integration: (1) solar feedwater pre-heating; (2) saturated steam generation with solar energy and post superheating in biomass steam generators; (3) superheated steam generation in parallel with biomass boilers. For the first two possibilities, LFC and parabolic trough collector were implemented, while in the third possibility it was implemented solar tower. The results demonstrated that the solar tower under the third layout provided the best LCOE (Levelized Cost of Energy) (220 US$/MWh). It is a satisfactory result considering the low DNI incident in the plant location (1502 kWh/m²-year). Other studies were developed in terms of technical and economic feasibility (Azevêdo *et al.*, 2017;

Souza e Cavalcanti, 2017; Sória *et al.*, 2015; Malagueta *et al.*, 2014). These studies point to the geographic location that allows the installation of CSP power plants. However, the interior of the northeastern region has limited accessibility due to the poor roads quality to transport the reflectors, and the reflectors have the higher cost of the solar field (~31 % of the total investment in a CSP plant). Thus, a viable solution to reduce the cost is to produce the reflectors and the receiver on-site (Soria *et al.,* 2015), without logistics issues and it would be possible to use a larger structure for the CSP power plant.

## 5. CONCLUSIONS

Solar concentration is one alternative for the use of solar irradiation for power generation. Linear Fresnel collector technology can generate electricity and supply the needed demand. Also, it is important to highlight that even LFC system is not the more efficient CSP technology, it has a good relation cost-benefit, once it has a simpler geometry, cheaper and easier maintenance, and a satisfactory thermal and optical performance. Beyond the operational LFC power plants, there are many under construction/development LFC projects and this fact indicates that there is a lot of interest in this technology.

Being a consolidated technology with a promising future, there is still a lot of space to improve its performance, once the LFC system can be widely explored, both geometric and thermal ways, as was confirmed through this work. Studies of optimization, comparison between different places, and works that explore different configurations for the system were presented.

Brazil is a country with high solar potential, and the implementation of LFC is latent and depends, mainly, on governmental policies. The present review summarized the current LFC research in the national scenario aiming at a more diversified and sustainable energy matrix. Brazil has not an LFC operating power plant, even there is an incentive for the installation, and these studies can be a booster for the development and construction of the first national CSP power plant.

## 6. ACKNOWLEDGEMENTS

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