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Review of a Solar Thermal Power Plant and their Potential Use in Libya

Araf Taher Almasri[1], Mohamed Fargani [2*] and Moutaz Alarida[3]

[1] Department of Mechanical Engineering Faculty of Engineering Tobruk University, Tobruk, Libya.
[2] Department of Mechanical Engineering Faculty of Engineering University of Derna, Derna Libya.
[3] Department of Mechanical Engineering Faculty of Engineering University of Omar Al Mukhtar, Albydya Libya

*Corresponding author: E-mail addresses: m.fargani@uod.edu.ly

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ABSTRACT

Given the significant worldwide usage of fossil fuels and the scarcity of traditional energy sources such as wood, coal, and gas, it has become critical to investigate alternative energy generating methods in order to solve environmental problems. Solar energy is one of the most well-known alternatives. Solar thermal power plants, a type of renewable energy technology, successfully capture the sun's energy to create electricity. These plants use mirrors or lenses to focus the sun's beams onto a receiver, which absorbs the heat and transforms it to thermal energy. This thermal energy is then converted into steam, which drives a turbine to generate electricity. Both small- and large-scale solar thermal power plants are feasible, and they provide a number of benefits over traditional energy sources, such as reduced greenhouse gas emissions, increased energy security, and cheaper energy prices. The intermittent nature of solar energy, the related expenses of the technology, and the possible effects on nearby species and the ecosystem all provide obstacles to the effective adoption of solar thermal power plants. Despite these difficulties, solar thermal power plants have the potential to be extremely important in the shift to a future where renewable and sustainable energy sources predominate.

1. INTRODUCTION

In Due to the massive increase in global population and the current state of the environment, alternative methods of providing electrical energy are imperative. According to advances in technology, the accessibility of fossil power will decrease over the coming decades due to the current utilization of electrical sources.

Structures called solar thermal power plants use sun energy to generate electricity. They employ mirrors or lenses to focus sunlight onto a small region, heating a fluid that is then used to generate electricity. Solar thermal power plants are a potentially useful source of renewable energy as compared to traditional fossil fuel-based power plants (Bauer T *et al*,2021),(Islam *et al*,2018), (Kassem *et al*, 2020). In comparison to other alternative energy resources, solar thermal energy (STE) facilities have the distinct benefit of being able to produce electricity on a big scale. Due to their performance in regions with plenty of sunlight, these cutting-edge plants are especially well-suited for nations in the sunbelt (Saleh *et al*,2006). Concentrated Solar Power (CSP) technology may offer a dependable and sustainable source of electricity in a nation like Libya, where solar radiation levels are among the highest in the world (Kalogirou *et al,*2023),(Behar *et al*,2013) CSP technology, used in solar thermal power plants, has the most promise for Libya's energy sector since it provides a sustainable, decentralised way to diversify the country's energy mix, cut greenhouse gas emissions, and improve energy security (Delucchi *et al*,2011). But for CSP to be successfully implemented in Libya, there must be a sizable investment, supporting legislation, and strategic partnerships to overcome the financial and technical obstacles that stand in the way of the nation's transition to a more renewable and sustainable energy future (Ion *et al*,1982).

1.1. How Solar Thermal Power Plant Work?

When considering the use of solar radiation for energy generation, solar thermal power and Photovoltaics (PV) systems are frequently discussed. To create and store energy, PV systems require a significant quantity of electrical gear and complicated silicon fabrication techniques. An alternate strategy, however, includes capturing solar heat to create mechanical energy, which is then converted into electrical energy using solar receivers, heat transfer devices, and the traditional Rankine cycle as shown in figure1 (Saleh *et al*,2006) , plants (Bauer *et al*,2021).

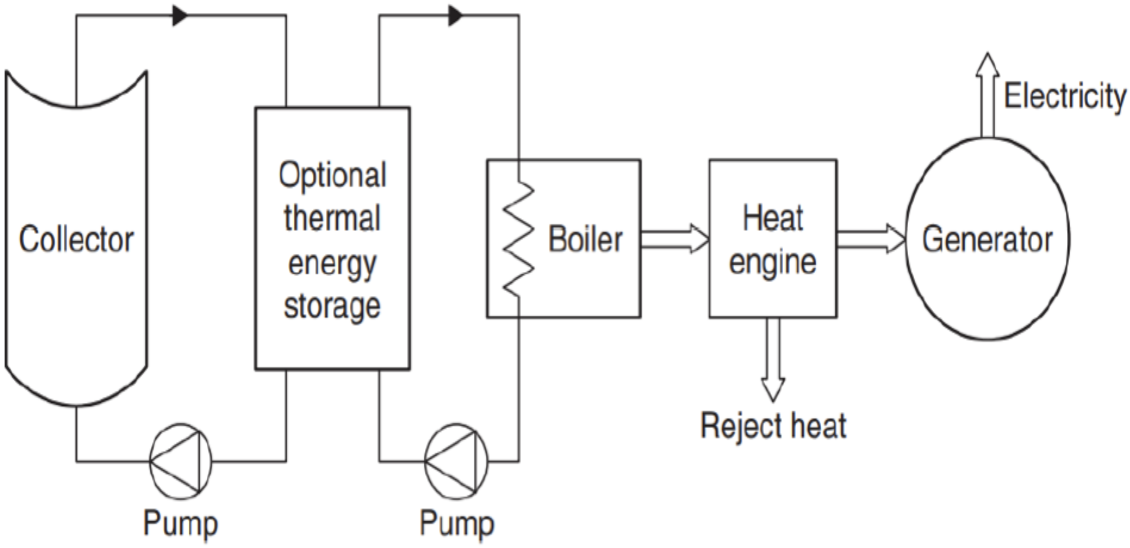


Figure. 1, The Basic Setup of Solar Thermal Conversion System (Islam *et al*, 2018).

This specific technique functions by catching and magnifying the thermal energy of the sun by using mirrors or lenses to focus sunlight onto a small region where it undergoes a conversion into high-temperature heat (Islam *et al*, 2018). The heat that has collected throughout this process is used to create steam, which is then used to turn a turbine and produce power. With this novel strategy, renewable and clean energy are produced by utilising the enormous power of solar radiation (DLR,2021), (Saleh *et al*,2006).

CSP works by focusing sunlight onto a receiver that is normally filled with a heat transfer fluid, such as molten salt, synthetic oil or air using mirrors or lenses. Utilising mirrors to focus the sun's rays to a temperature generally between 400°C and 1000°C, the fluid is heated to high degrees by the concentrated sunlight, which may then be stored and utilised to produce power even when the sun's not shining (Kraemer , 2018).

The subsequent process uses the heat transfer fluid to create steam, which powers a turbine and releases energy. This procedure is similar to how conventional power plants operate, however instead of heating the fluid using fossil fuels, heat is produced by the sun's rays. With a number of advantages over conventional energy sources, CSP technology may be deployed on a small or big scale (Navarro *et al*, 2016). A significant quantity of direct sunshine is needed for solar energy project locations to be suitable; this number often exceeds 2,000 kWh of solar radiation per square meter per year. However, the most advantageous places offer even greater values, exceeding 2,800 kWh/m^2/year. These numbers are used as a benchmark for locating regions with the best solar resources and the greatest potential for harvesting solar energy (Bauer *et al*,2021). Additionally, CSP's ability to store thermal energy in the heat transfer fluid allows it to generate electricity even when the sun isn't shining. As a result, CSP is a very dependable form of renewable energy (Saleh *et al*,2006).

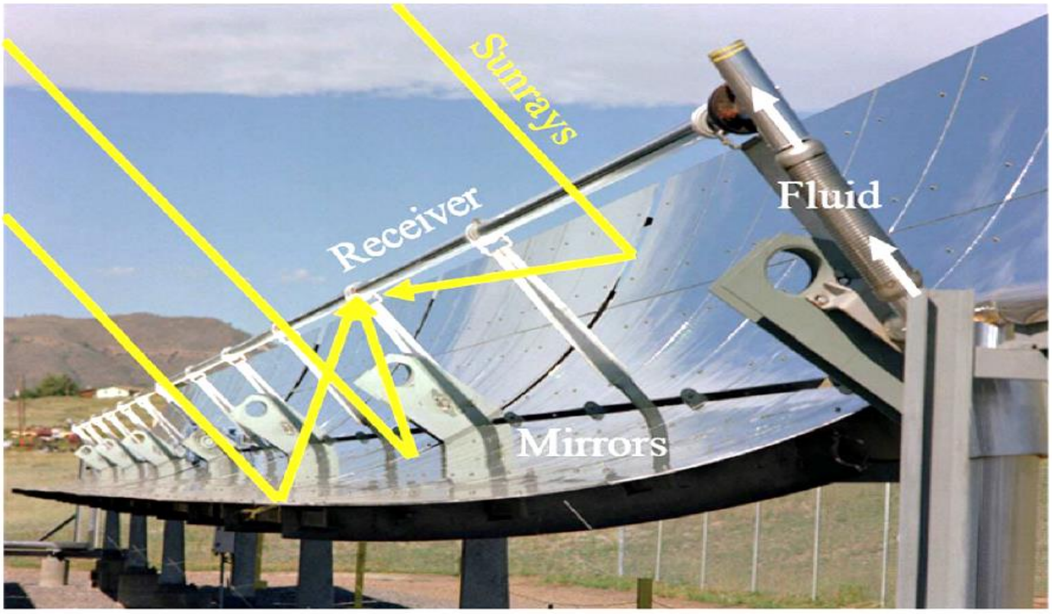


Figure. 2 Parabolic Trough Solar Collector (Ehtiwesh *et al*,2018)

It is crucial to keep in mind that the present investment prices for contemporary battery storage systems are still rather high, coming in at about $300 per kilowatt-hour (Gorjian *et al*,2015). Additionally, the service life of these systems is short—less than 10 years. Molten salt storage tanks are now the main technique used to store thermal energy in solar thermal power facilities. Large containers up to 40 meters in diameter and 15 meters in height make up these tanks (García *et al,*2018). The heat storage medium in these containers is a solution of potassium nitrate and sodium nitrate (Belgasim *et al*, 2014). The salt is heated by the solar energy that is collected, reaching temperatures of up to 560 °C after melting at 250 °C (Gorjian *et al*, 2015). The tank's thermal energy is channeled toward a steam generator when power generation is necessary. Modern solar thermal power systems frequently have storage capacities between six and fifteen full-load hours. This large amount of storage makes it possible to run continuously throughout the day or, more especially, during moments of peak power consumption (Bauer *et al*, 2021).

With a global installed capacity of about six gigawatts in 2020, solar thermal power plants are still in the early phases of market introduction. This stage of development is comparable to where PVs were 15 years ago or wind energy 25 years ago, demonstrating the potential for additional development and expansion in the industry(Kassem *et al* ,2020) , (Saleh *et al*, 2006). Although wind energy and PV systems make a substantial contribution to the rising amount of electricity produced from renewable sources, their output is erratic due to variations in wind and solar radiation. To reduce these variations, there are currently no commercially feasible large-scale power storage options (Kassem *et al*, 2020) . Solar thermal power plants, on the other hand, provide an alternative strategy of storing heat rather than electricity, which works out to be around 80% to 90% less expensive. This innovative approach enables the generation of solar power even during periods when sunlight is not available (Bauer *et al*, 2021).

1.2. Types of Solar Thermal Power Plants

There are several types of solar thermal power generation technologies, each with its own unique advantages and disadvantages. The most popular types of CSP facilities are the parabolic trough, power tower, linear Fresnel, and dish/Stirling systems.

The most advanced method, called a parabolic trough system, for parabolic trough systems, the usual concentration ratio lies between 50 and 100 times the original solar intensity. Scale-wise, parabolic trough power plants can range from modest pilot projects with power outputs of a few megawatts (MW) to substantial commercial facilities with outputs of 30-350 MW, with 21% unit efficiency (Bauer *et al*,2021), (Kassem *et al* ,2020), (Kalogirou *et al*,2023), (Usón *et al*,2019). Power tower systems, on the other hand, employ a collection of mirrors or heliostats to reflect sunlight onto a central receiver at the top of a tower, where the heat is gathered and used to make steam that powers a turbine to produce energy. When compared to parabolic trough systems, solar power tower plants have a greater concentration ratio that generally ranges from 300 to 1,500 times the original sunshine intensity. Tower solar power plants generally have capacities between 30-100 MW and a unit efficiency of 23%, making them bigger in terms of size. Similar to parabolic trough systems, Tower solar power plants focus sunlight through flat mirrors onto a linear receiver, which then warms a working fluid to produce energy. This technology's ability to reach high temperatures allows it to be flexible enough to power various power cycles, such as steam Rankine and Brayton cycles. In order to continue producing electricity after the sun sets, these systems can also be connected with TES systems (Jamshidian *et al*, 2018),(Alobaidi *et al*,2020),(Baharoon *et al*,2015), (Behar *et al*,2013). Linear Fresnels are utilised in solar thermal power facilities. Directing sunlight onto a linear receiver using a collection of flat mirrors, or reflectors. To optimise the concentration of solar radiation onto the receiver, the reflectors are placed in a line and move with the sun throughout the day. The heat-absorbing tube or pipe in the receiver is located above the reflectors. The fluid travelling through the tube, usually water or oil, warms up when the concentrated sunlight reaches the receiver. Once the fluid has been heated, it is utilised to create steam, which powers a turbine attached to an electrical generator to provide electricity. displaying a 15–150 concentration range and boasting a stunning 20 % unit efficiency. Additionally, Fresnel's operational range, which ranges from 10 to 320 MW, demonstrates its adaptability for a variety of power producing capabilities.

Last but not least, dish/Stirling systems employ a parabolic dish to direct sunlight onto a Stirling engine, which transforms the heat into mechanical energy used to power a generator, with 5-6 MW of capacities and a concentration ratio between 600 and 3000 and with unit efficiency of 30% (Besisbo *et al* ,2009), (Bauer *et al*,2021) ,(Islam *et al*,2018),(Kassem *et al*,2020), (Saleh *et al*,2006), (Usón *et al*,2019).

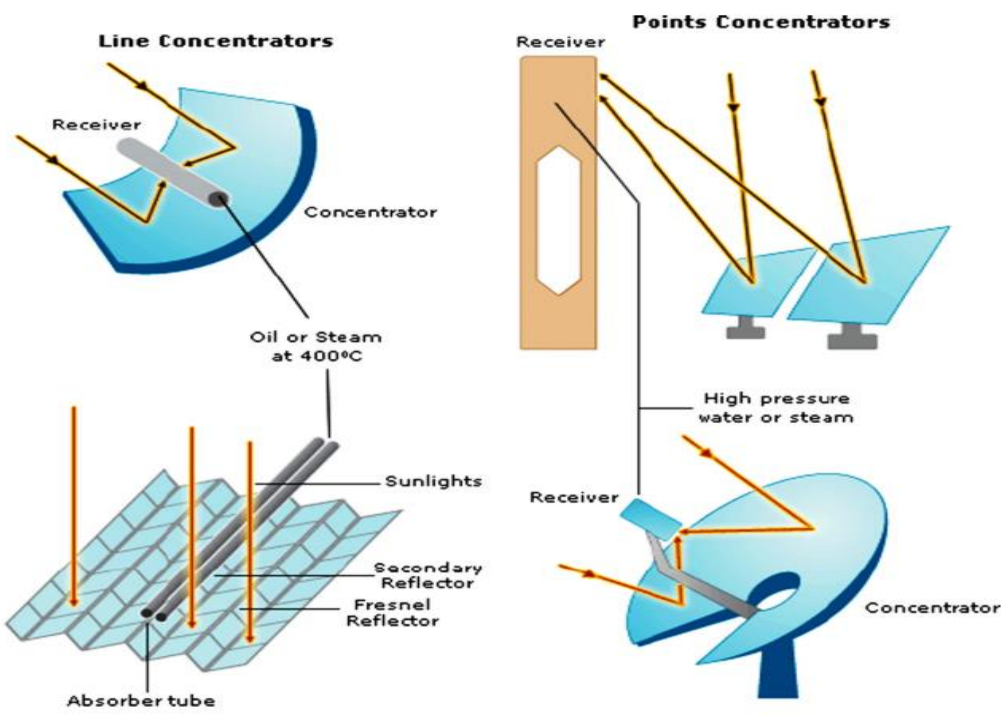


Figure. 3, Example of Concentrating Solar Power system (Powell et al, 2017)

Point focusing systems and line focusing systems are two more categories for CSP systems. Dish/Stirling systems frequently employ point focusing devices, which concentrate sunlight onto a single point or area. However, line focusing systems, which are frequently employed in parabolic trough, power tower, and linear Fresnel systems, focus sunlight onto a line or narrow area (Pitchumani *et al,*2017). While in line focusing systems, mirrors or reflectors are arranged to concentrate sunlight onto a linear receiver or tube, they are used in point focusing systems to direct sunlight onto a receiver that is situated at the focal point of the system. The geographical location, resources that are accessible, and the planned use of the generated electricity are just a few of the variables that must be taken into consideration when choosing the best CSP system type (Renewable Energy in Libya, 2012).

Line focusing systems are often employed in larger-scale commercial applications, whilst point focusing systems are frequently used in smaller-scale applications or as a component of hybrid systems (Usón *et al*,2019).

1.3. How Can Technical Innovations Further Reduce Costs

Obstacle in the development of solar thermal power facilities regarding reference solar power plants, costs for capacity investments, heliostat fields, receiver and steam generator systems, tower assembly and commissioning, design and engineering, consulting, and various other costs all go into the total investment and operating costs as well as the resulting power generation costs. The following are some crucial areas where innovation may assist in cost-cutting:

- Materials: Solar thermal power plants may be built and operated for a lower price through the utilisation of modern materials such lightweight, durable components. For instance, using lightweight lenses or mirrors can enable the equipment to be lighter, simpler to carry, and more affordable to assemble.
- Concentrating Technologies: By increasing their effectiveness, concentrating technologies like mirrors and lenses can help bring down the price of STE. For instance, using monitoring techniques that are cheaper and more efficient can maximize the quantity of energy that can be produced from a specific area of solar panels.
- Thermal Energy Storage: By enabling energy to be stored and used when it is required rather than when it is generated, thermal energy storage systems with increased efficiency can help bring down the price of solar thermal power. Utilising cutting-edge materials and insulation methods, for instance, can lower the price of thermal energy storage.
- Operations and maintenance: Increasing the effectiveness of operations and maintenance procedures can also assist in lowering the price of STE. Predictive maintenance methods and automation, for instance, can save repair and maintenance costs while enhancing the technology's dependability.

Inclusive, researchers, inventors, and manufacturers in this sector are concentrating on this issue because of the tremendous potential for technological advancements to lower the prices of solar thermal power (Bauer *et al*, 2021), (Gorjian *et al*, 2015), (Islam *et al*, 2018), (Kassem *et al*, 2020), (Renewable Energy in Libya, 2012).

2. Solar Thermal Power Plants in Libya

It is becoming more and more obvious that a switch to renewable energy sources is required to lessen the impact of greenhouse gas emissions as the globe grapples with the issue of climate change. For nations with lots of sunshine, like Libya, that want to diversify their energy sources, solar thermal power plants offer a viable choice (Baharoon *et al,*2015), (Ion,1982), (Purohit *et al*, 2020), (Stackhouse, 2018). According to information from The Centre for Solar Energy Research and Studies, solar energy is significant as a valued resource in Libya. Due to its geographic placement along the cancer orbit line, the nation has prolonged daylight hours and year-round exposure to sun radiation. The country is considered affluent in terms of its solar radiation resources. The distribution map in Figures 4 and 5 depicts the average yearly Global Horizontal Irradiation (GHI) and Direct Normal Irradiation (DNI) throughout the country. These measurements were collected and averaged by Solar GIS between 1994 and 2010. It is evident from the data that the average annual GHI ranges from 2000 kWh/m^2/year in the Northern regions to over 2600 kWh/m^2/year in the Southern regions. The average yearly Direct Normal Irradiance (DNI) ranges from approximately 1900 kWh/m^2/year in the coastal region to 2500 kWh/m^2/year in the South, as reported in sources (Belgasim *et al*, 2018), (Belgasim *et al*, 2014). Additionally, according to Hall (Behar *et al*,2013), (Ion,1982), (Saleh *et al*, 2006) the average yearly solar exposure is greater than 3500 hours.

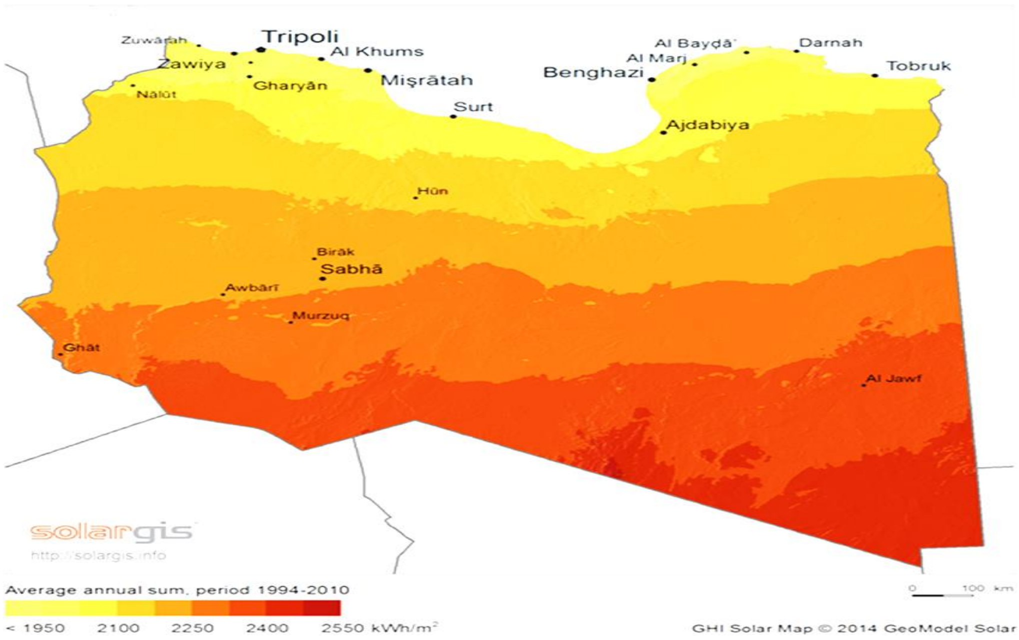


Fig4. Average global horizontal irradiation (GHI) in Libya (Solar GIS,2024)

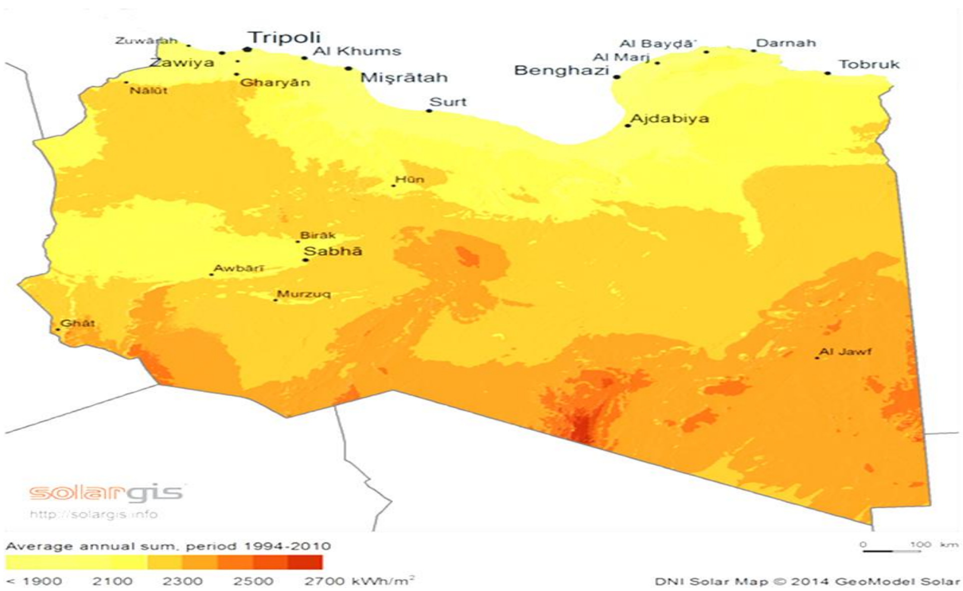


Figure 5,Average direct normal irradiation (DNI) in Libya (Solar GIS,2024)

In light of these advantageous circumstances, solar energy has enormous potential for use in the nation as a whole, including the use of PV cells, solar thermal power, water desalination, and several other uses (Saleh *et al*, 2006), (Saleh *et al*, 2006).

However, the sector needs sizable private investments and a legislative framework that is more supportive of these goals if it is to effectively achieve renewable energy targets and the urgent need for sustainable development. The establishment of a supportive environment that encourages competitive bidding procedures and the negotiation of long-term power purchase agreements is necessary to facilitate the participation of renewable energy companies.

According to many researchers (Bauer *et al*, 2021), (Ehtiwesh *et al*, 2018), these steps are essential to getting the desired results in the renewable energy business.

Solar thermal power plants have the ability to boost economic growth and create jobs, a large number of skilled and unskilled labour, as well as support services like transportation and maintenance, are needed for the building and operation of these power plants, which opens up employment possibilities for local residents and companies and boosts economic activity and prosperity (Bauer *et al*, 2021). Solar thermal power plants can also aid in lessening Libya's reliance on fossil fuels, which is now a major weakness for the nation. Libya may diversify its economy and lessen its dependency on oil exports by investing in renewable energy, improving energy security and economic stability (Alobaidi *et al*, 2020), (Behar *et al*, 2013), (Liu, 2019).

The establishment of solar thermal power stations in Libya might be significantly aided by the oil sector (Delucchi et al, 2011). It is conceivable to use the money generated by the petroleum industry to fund renewable energy initiatives like solar thermal power facilities. In addition, petroleum may be used to construct distribution and transmission lines and other types of energy infrastructure that support renewable energy, opening up previously unreachable rural places to renewable energy. The growth of solar thermal power plants may also be supported by petroleum, which might assist to increase the technology's effectiveness and affordability (Alobaidi *et al*, 2020). Analyzing the solar power facilities in Morocco that exhibit notable advancements with 515 MW and 45% more parabolic trough systems overall (Kassem *et al*, 2020).

CSP systems come in a variety of forms, and each has pros and cons. The degree of sun irradiation, the accessibility to transmission lines, and the availability of land all play a role in determining the optimal CSP system for Libya (Navarro *et al*, 2016). The parabolic trough system is one kind of CSP technology that Libya may be able to use. With annual expected electricity production of 10,000 GWh, the parabolic trough allows sunlight to be focused onto a receiver tube at the focal point of the mirror using this method, which makes use of parabolic mirrors [(Purohit et al, 2020). Systems using a parabolic trough are trustworthy and have been used in a number of nations, including Spain, the United States, and Morocco. In Libya, which has many flat desert terrains, they are also well suited. The parabolic trough systems are intended to be simple to install and maintain in such circumstances thanks to their design. They can endure the sweltering heat and hostile environmental conditions that are typical in desert areas (Stackhouse, 2018).

The continuous flow of energy depends on the parabolic trough technology's large thermal storage capacity. The system has the capacity to store excess daytime energy as heat, which may later be converted into electricity at night or when there is no sunlight (Bauer et al,2021), (Saleh et al,2006). This suggests that parabolic trough systems may still provide a consistent and stable source of electricity even when the sun is not shining. Furthermore, the parabolic trough system is the best CSP technology for Libya due to its high efficiency, reliable track record, flexibility for dry locations, and substantial thermal storage capacity (Jamshidian et al, 2018),(Stackhouse, 2018), (Usón et al, 2019).

These technologies are especially well suited for the area given Libya's predominately level desert landscape. Systems using parabolic troughs are suited for such climatic conditions because of their simple installation and maintenance requirements. These systems demonstrate resilience in withstanding the intense heat and difficult climatic conditions typical of desert regions (Tardioli et al, 2017).

3. How Can Solar Thermal Power Plants be Installed in Libya?

Libya has a substantial richness of renewable resources, offering a wonderful chance to diversify its domestic energy supply and implement decentralised power systems. The government has set a lofty goal of generating 22% of its power from renewable sources by 2030, which is in keeping with the forward-looking targets defined by the General Authority for power and Renewable Energy. This strategic vision places a strong emphasis on increasing the availability of renewable energy, with a concentration on the solar and wind energy sectors in particular (Belgasim et al, 2018), (Bauer et al, 2021), (Delucchi et al, 2011), (Kassem et al, 2020).

The first phase is to seek funding for the building of the power plants when acceptable locations have been found. Libya is the perfect site for solar thermal power plants since it has vast desert regions. Libya now generates a sizable 33 TWh of energy to satisfy the rising electrical demand (Liu, 2019), (Reddy et al, 2020). However, the industry requires a major infusion of private investments and a more accommodating regulatory framework from the government in order to meet renewable energy objectives and fulfil the urgent need for sustainable development. In order to facilitate the participation of renewable energy developers, this means establishing an atmosphere favourable to competitive bidding procedures and the formation of long-term power purchase agreements (Tardioli et al, 2017).

The amount of sun irradiation, the availability of land, and the proximity to transmission lines all affect how suitable a location is for a solar thermal power plant.

Large tracts of flat desert ground are also present in the area, making them ideal for the development of solar thermal power facilities. Government finance, private investment, and foreign aid can all be used to do this (Ion,1982).

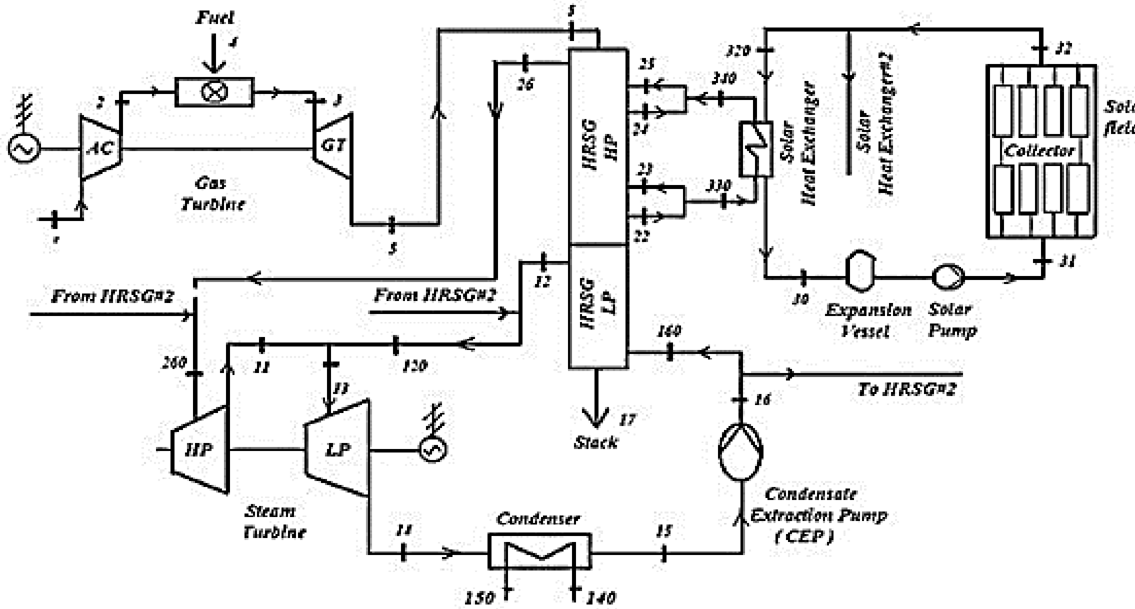
The building of the power plants can start once funding has been obtained. Site preparation, the installation of solar collectors and thermal storage systems, and the creation of a power block to transform thermal energy into electricity are the usual steps of this procedure. In order to assure the dependability and lifespan of the power plants, it is crucial to use qualified people and high-quality materials. Once the power plants are built, they must be linked to the country's electrical infrastructure. In order to ensure that the electricity produced by the power plants can be delivered throughout the nation, this may need the building of new transmission lines or the extension of existing ones. To maximise their effectiveness and longevity, it's crucial to make sure the power plants are properly maintained and run (Ion,1982). However, it is becoming clear that CSP has higher promise for sustainable energy generation (DLR, 2021). CSP creates high temperatures that may be utilised to generate energy by concentrating sunlight into a tiny area using mirrors or lenses. CSP is an excellent technology for Libya because of its many benefits.

The ability to store energy, which is necessary for a steady supply of electricity, is another benefit of CSP technology for Libya. Libya has one of the highest DNIs in the world. Because of this, it is the ideal location for using CSP technology (Bauer et al, 2021), (Liu, 2019).

Due to its high solar irradiation levels, energy storage capabilities, minimal environmental effect, and potential for job creation and economic growth, CSP technology is, all things considered, the ideal way for generating electricity in Libya (Reddy et al, 2020).

3.1. Hybridization a CSP with Gas Turbine

In solar thermal power plants, the idea of hybridization entails combining solar energy with heat obtained from other sources, such biomass or fossil fuel power plants. Hybridization has a number of benefits, such as improved solar power conversion efficiency, improved dispatchability to meet peak demand and supply energy as needed, and the capacity to reduce solar radiation fluctuation (DLR, 2021). Utilising hybrid power production systems is crucial since it has a substantial impact on both social and technological factors. While gas turbine power plants and hybrid systems have grown in popularity, solar thermal power still has year-round energy unpredictability. These hybrid systems work as an alternative to conventional storage methods, successfully reducing volatility in the energy supply and the gap between energy output and demand. In order to overcome problems with solar availability and satisfy load demand, hybrid power production systems rely on stored energy (Besisbo, 2009), (DLR, 2021), (Kraemer, 2018), (Makkiabadi et al, 2021). Operating similarly to a traditional combined cycle power plant such as Yazd power plant in Iran, the Integrated Solar Combined Cycle station (ISCCS) power plant's main difference is the addition of solar energy. As shown in figure 4, the exhaust from the gas turbine and the solar parabolic trough field may both help with the steam generation for the steam turbine in an ISCCPP. In contrast to a traditional combined cycle power plant, the ISCC power plant's integration of solar energy enables the generation of steam at greater pressures and temperatures, which maximises the use of solar energy (Liu, 2016), (Saleh, 2006).



Figure, 4. Schematic diagram of ISCCS in Yazd, Iran (DLR, 2021)

3.2. Main Components of Parabolic Trough

The basic idea of the parabolic trough solar system comprises concentrating incident sunlight onto a linear parabolic reflector, which then directs the focused light into a pipe-shaped receiver. This system's receivers are made of steel circular tubing covered in a vacuum glass covering, which is strategically engineered to limit heat loss. These pipes are filled with synthetic oil, which acts as a heat transfer medium in the system's heating loop (Baharoon et al, 2015).

The oil is sent to a heat exchanger within the heating loop, and the thermal energy that is transmitted there is used to power a typical turbine that produces electricity (Kassem et al, 2020). It is standard practice to connect a parabolic trough collector with either a gas turbine power plant or a natural gas heating system in order to improve the predictability and dependability of power generation. A gas turbine power plant or a natural gas heating system is frequently paired with a parabolic trough collector to provide a system with more predictable and dependable power generation, as shown in Fig. 5 below (DLR, 2021).

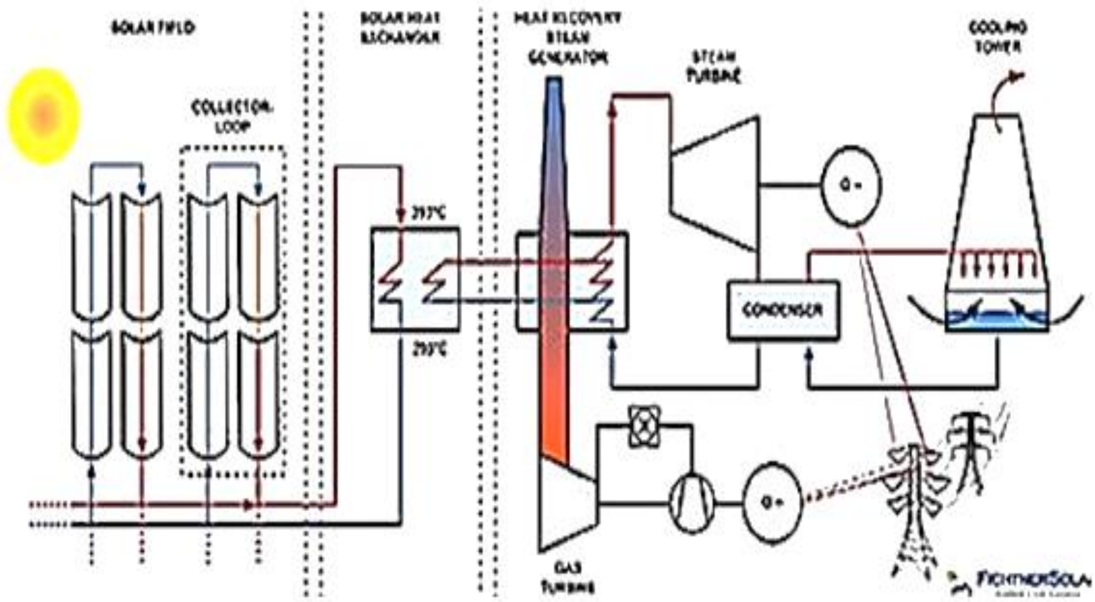


Figure 5. Integrated solar combined cycle power plant (DLR, 2021)

In the parabolic trough solar system, the correct alignment of sunlight onto the receiver is crucial, and this goal can only be achieved by the painstaking tracking and movement of heliostats. It is crucial to remember that "sun-tracking" for a heliostat requires keeping the focus of the sun's reflection precisely at the receiver in addition to maintaining a perpendicular orientation to the sun's rays (Islam et al, 2018), (Kassem et al, 2020).

The system uses steel tubes called receivers, which typically have a diameter of 70 mm. These tubes have vacuum glass jackets and selective coatings, which improve heat transmission and reduce heat loss, respectively. The most complex part of the solar capture mechanism is the tracking system of the parabolic trough, which includes drive motors, sensors, and control systems. The fact that these tracking systems work along a single axis makes them simpler than other sun-tracking systems, it should be mentioned (Bauer et al, 2021), (Kassem et al, 2020).

Light-sensitive diodes are used to compare solar radiation levels to determine where to place the collectors. The controller sends a signal to modify the location of the collectors if any discrepancies are found by the sensors. Fluid transfer pumps, traditional power production devices like turbines and generators, auxiliary heaters powered by natural gas, complete control systems, and other parts of the system are also very important (Islam et al, 2018).

The parabolic forms of low iron, black-silvered float glass are commonly used in the construction of the reflector mirrors utilised in the system. To increase their lifespan, these reflectors' back surfaces include protective coatings like lacquer or other coatings.

For the best sun tracking, these glass panels are set on truss systems powered by hydraulic motors. The maintenance of the solar collecting system is of highest significance; hence the majority of facilities have mechanical systems in place for routine mirror cleaning (Kassem et al, 2020).

It is critical to recognize that modern battery backup systems still have very significant investment costs, averaging three hundred dollars per kilowatt-hour. Furthermore, the operational life of such equipment is quite limited, spanning less than a decade. Molten salt storage tanks have evolved as the major way of storing thermal energy in solar thermal power plants. One advantage of such structures is their capacity to retain heat inside the molten salt, allowing them to be used in both rainy and sunny settings (Bauer et al, 2021).

The size of these storage tanks, which may have up to 40-metre diameters and 15-metre heights, is made up of enormous containers. The mixture of potassium and sodium nitrates used in these containers serves as the heat storage medium (Belgasim et al, 2014). After melting at 250 °C, the salt is heated by solar energy, reaching a maximum temperature of 560 °C (Bauer et al, 2021). When power generation is required, thermal energy from the tank is directed toward a steam generator, which then fuels the functioning of a standard steam turbine. Storage capacity in contemporary solar thermal power systems generally vary between six and fifteen full-load hours, permitting operation to continue throughout the day and, more significantly, during times of peak power use (Bauer et al, 2021).

Through the receivers and into a bigger header that is attached to a heat exchanger, the synthetic oil (heat transfer fluid) is pumped. It is possible to raise the temperature of the oil before using this heat exchanger using an auxiliary heater that is powered by natural gas or a gas turbine. High pressure steam is created by the heat exchanger by transferring heat from concentrated solar energy to water.

The steam generated is utilised to generate electricity using a standard Rankine cycle. Having these plants mostly located in arid regions, where there aren't any sizable bodies of water that may be utilised as condenser water, is a prevalent problem (Belgasim et al, 2014).

4. Advantages and Disadvantages

Solar power plants are equipped with renewable energy properties thanks to the use of sunshine as a heating technique. Fuel expenditures are also eliminated, guaranteeing cheap running costs. Since the operation of these systems depends on the availability of sunlight, they are not totally predictable, although continuous developments are increasing their dependability. The integration of molten salt storage systems makes it possible to store extra energy, and the addition of auxiliary heaters improves dependability even further (Islam et al, 2018), (Kassem et al, 2020), (Renewable Energy in Libya, 2012).

Nonetheless, there are several downsides to these systems. They contain a significant amount of oil, which raises the danger of leakage and probable soil contamination from an environmental standpoint. Furthermore, the land footprint required by these plants per unit of electricity generated is comparable to other types of power plants. Furthermore, due to the lack of water supplies, the adoption of traditional condenser systems becomes impossible due to the desert-like conditions often associated with their geographical locations. While massive forced-draft cooling towers can alleviate this restriction, they are more expensive than standard condenser systems.

Finally, because these systems are frequently combined with auxiliary heaters, they are not totally emission-free power plants (Bauer et al, 2021).

5. Conclusion

Conclusively, solar thermal power generating technologies constitute a potential strategy for capturing the sun's energy for electricity production. Solar thermal power stations have grown to be a feasible option to satisfy energy demands sustainably as a result of the growing need for renewable energy sources.

there is a rising demand for solar thermal power plants, and many sizable projects are already under way in a variety of parts of the world. These initiatives show the viability and efficiency of solar thermal power plants as a renewable energy source (Singh et al, 2017).

Even though solar thermal power plants are now competitively priced with other renewable energy sources, additional technological advancements may assist to further bring down prices. For instance, improvements in materials science and manufacturing methods may result in more efficient and affordable solar thermal power plant components.

Overall, the worldwide move to a more sustainable energy future relies heavily on solar thermal power facilities. These technologies have the potential to be extremely important in lessening reliance on fossil fuels and lowering the effects of climate change by offering a source of renewable energy that is both affordable and reliable.

Furthermore, Libya's energy industry has long been dependent on the nation's enormous crude oil reserves, but the switch to renewable energy is becoming more and more important in order to lessen the effects of greenhouse gas emissions.

For nations like Libya that have an abundance of sunshine and a desire to diversify their energy mix, solar thermal power plants present a viable option.

Investments in solar thermal power plants may boost the local economy, provide jobs for residents, lessen the nation's reliance on fossil fuels, and assist in the shift to a low-carbon economy.

Utilising its financial resources to make investments in renewable energy projects, establish energy infrastructure that can support energy from renewable sources, and fund research and development, the petroleum industry may play a significant role in assisting the development of solar thermal power plants.

6. REFERENCES

Jamshidian, F. J., Gorjian, S., & Far, M. S. (2018). An overview of solar thermal power generation systems.

Alobaidi, S. M., Al Mabrouk, A., & Al-Shafei, A. (2020). Renewable energy sources in Libya: An overview. *Journal of Sustainable Energy and Sustainable Development*, 7(2), 65-76. https://jsesd-ojs.csers.ly/ojs/index.php/jsesd/article/view/74

Baharoon, D. A., Rahman, H. A., Omar, W. Z. W., & Fadhl, S. O. (2015). Historical development of concentrating solar power technologies to generate clean electricity efficiently–A review. *Renewable and Sustainable Energy Reviews*, 41, 996-1027.

Behar, O., Khellaf, A., & Mohammedi, K. (2013). A review of studies on central receiver solar thermal power plants. *Renewable and sustainable energy reviews*, 23, 12-39.

Belgasim, B., Aldali, Y., Abdunnabi, M. J. R., Hashem, G., & Hossin, K. 2018. The potential of concentrating solar power (CSP) for electricity generation in Libya. *Renewable and Sustainable Energy Reviews*, 90: 1–15.

Belgasim, B., & Elmnefi, M. (2014). Evaluation of a solar parabolic trough power plant under climate conditions in libya. In *13th International Conference on Sustainable Energy Technologies (SET2014)* (p. 1).

Besisbo Faraj. (2009). Alternative energy sources and its role in the production of electric power in Libya, *Research Centre for Renewable Energy and Water Desalination – Tajoura*

Bauer, T., Odenthal, C., & Bonk, A. (2021). Molten salt storage for power generation. *Chemie Ingenieur Technik*, 93(4), 534-546.

Delucchi, M. A., & Jacobson, M. Z. (2011). Providing all global energy with wind, water, and solar power, Part II: Reliability, system and transmission costs, and policies. *Energy Policy,* 39(3), 1170-1190. https://doi.org/10.1016/j.enpol.2010.11.045

DLR – Study solar thermal power (CSP). (2021, January 20). *Retrieved from https://www.dlr.de/en/latest/news/2021/01/20210330_study-solar-thermal-power*

Ehtiwesh, I. A. S., Neto Da Silva, F., & Sousa, A. C. M. 2018. Deployment of parabolic trough concentrated solar power plants in North Africa – a case study for Libya. *International Journal of Green Energy*, 16(1): 72–85.

Gorjian, S., & Ghobadian, B. (2015). Solar Thermal Power Plants: Progress and Prospects in Iran. *Energy Procedia*, 75, 533–539.

García-Rodríguez, L., Silva, L., Torres-Rodríguez, M. A., & González-Delgado, A. D. (2018). Economic evaluation of parabolic trough collector solar power plants with a comparison between three different solar multiple configurations. *Renewable Energy*, 126, 1113-1123. https://doi.org/10.1016/j.renene.2018.04.075.

Guo, J., Huai, X., & Cheng, K. 2018. The comparative analysis on thermal storage systems for solar power with direct steam generation. *Renewable Energy*, 115: 217–225.

Ion, D. C. 1982. Book Review: Energy — A Global Outlook, Energy — A Global Outlook: The Case for Effective International Cooperation. *Energy Exploration & Exploitation*, 1(4): 331–333.

Islam, M. T., Huda, N., Abdullah, A. B., & Saidur, R. (2018). A comprehensive review of state-of-the-art concentrating solar power (CSP) technologies: Current status and research trends. *Renewable and Sustainable Energy Reviews*, 91, 987-1018. https://doi.org/10.1016/j.rser.2018.04.074.

Kassem, Y., Çamur, H., & Aateg, R. A. F. 2020. Exploring Solar and Wind Energy as a Power Generation Source for Solving the Electricity Crisis in Libya. *Energies*, 13(14): 3708.

Kalogirou, S. A. (2023). *Solar energy engineering: processes and systems*. Elsevier.

Kraemer, S. (2018, October 17). Solar Thermal Electricity Global Outlook 2016. Retrieved from https://www.solarpaces.org/solar-thermal-electricity-global-outlook-2016

Liu, Y., Li, F., Ren, J., Ren, G., Shen, H., & Liu, G. (2019). Solar thermal power generation technology research. *E3S Web of Conferences*, 136.

Liu, M., Steven Tay, N., Bell, S., Belusko, M., Jacob, R., Will, G., ... Bruno, F. (2016). Review on concentrating solar power plants and new developments in high temperature thermal energy storage technologies. *Renewable and Sustainable Energy Reviews*, 53, 1411–1432.

Mohamed, A. M., Al-Habaibeh, A., & Abdo, H. (2013). An investigation into the current utilisation and prospective of renewable energy resources and technologies in Libya. *Renewable Energy*, 50, 732–740.

Makkiabadi, M., Hoseinzadeh, S., Taghavirashidizadeh, A., Soleimaninezhad, M., Kamyabi, M., Hajabdollahi, H., ... & Piras, G. (2021). Performance evaluation of solar power plants: a review and a case study. *Processes*, *9*(12), 2253.

Navarro, A. A., Ramírez, L., Domínguez, P., Blanco, M., Polo, J., et al. 2016. Review and validation of Solar Thermal Electricity potential methodologies. *Energy Conversion and Management,* 126: 42–50.

Pavlović, T. M., Radonjić, I. S., Milosavljević, D. D., & Pantić, L. S. (2012). A review of concentrating solar power plants in the world and their potential use in Serbia. *Renewable and Sustainable Energy Reviews,* 16(6), 3891-3902.

Pelay, U., Luo, L., Fan, Y., Stitou, D., & Rood, M. (2017). Thermal energy storage systems for concentrated solar power plants. *Renewable and Sustainable Energy Reviews*, 79, 82–100.

Pitchumani, R. 2017. Progress in Solar Energy Special Issue: Advances in Concentrating Solar Power. *Solar Energy*, 152: 1–2.

Powell, K. M., Rashid, K., Ellingwood, K., Tuttle, J., & Iverson, B. D. 2017. Hybrid concentrated solar thermal power systems: A review. *Renewable and Sustainable Energy Reviews,* 80: 215–237.

Purohit, I., & Purohit, P. (2020). Solar thermal power plants: Recent developments and future prospects. *Renewable Energy*, 146, 2315-2330. https://doi.org/10.1016/j.renene.2019.09.143.

Reddy, K. S., & Ananthsornaraj, C. 2020. Design, development and performance investigation of solar Parabolic Trough Collector for large-scale solar power plants. *Renewable Energy*, 146: 1943–1957.

Răboacă, M. S., Badea, G., Enache, A., Filote, C., Răsoi, G., Rata, M.,Felseghi, R. A. (2019). Concentrating Solar Power Technologies. *Energies*, 12(6), 1048.

Renewable Energy in Libya (The Future Prospectives) Wednesday 28 th of March 2012 Amman, Jordan Eng. n.d. . https://slideplayer.com/slide/4458382/.

Saleh, I. (2006). Prospects of Renewable Energy in Libya. *The International Symposium on Solar Physics and Solar Eclipses* (SPSE 2006).

Saleh, R., & Nickel, N. H. (2006). Structural properties of phosphorous-doped polycrystalline silicon. *Solar Energy Materials and Solar Cells*, 90(18–19): 3456–3463.

Singh, D. B., & Tiwari, G. N. 2017. Performance analysis of basin type solar stills integrated with N identical photovoltaic thermal (PVT) compound parabolic concentrator (CPC) collectors: A comparative study. *Solar Energy*, 142: 144–158.

Singh, S. K., Tiwari, G. N., & Singh, B. (2017). Review of solar thermal power plant technologies based on parabolic trough and fresnel collectors. *Renewable and Sustainable Energy Reviews,* 72, 693-706. https://doi.org/10.1016/j.rser.2016.10.019.

Thompson, C. (2017). Renewable energy in Libya: An unexplored market for the future. *DemocracyLab* https://www.democracylab.uwo.ca/Archives/2016__2017_research_/oil_and_energy_in_libya/renewable_energy_in_libya_an_unexplored_market_for_the_future.html.

SolarGIS. Solar resource maps for Libya: Global Horizontal Irradiation (GHI). *SolarGIS;* 2014. ⟨http://solargis.info/doc/free-solar-radiation-maps⟩ .

Stackhouse P. Surface meteorology and Solar Energy. NASA Applied Sciences Program, (https://eosweb.larc.nasa.gov/sse/).

Tardioli, C., Rognoni, L., & Eyer, J. (2017). Environmental sustainability of concentrating solar power plants in developing countries. *Applied Energy*, 189, 152-167. https://doi.org/10.1016/j.apenergy.2016.11.075.

Usón, S., Uche, J., Martínez, A., del Amo, A., Acevedo, L., et al. 2019. Exergy assessment and exergy cost analysis of a renewable-based and hybrid trigeneration scheme for domestic water and energy supply. *Energy*, 168: 662–683.

Vant-Hull, L. L., & Stein, K. L. (2012). Concentrating solar power technology: principles, developments and applications. Concentrating solar power technology: principles, developments and applications. Ed. by Keith Lovegrove and Wes Stein. Cambridge, UK: *Wood head Publishing,* 240-283.

Vengadesan, E., & Senthil, R. 2020. A review on recent developments in thermal performance enhancement methods of flat plate solar air collector. *Renewable and Sustainable Energy Reviews,* 134: 110315.

Williams, B. G. (n.d.). Parabolic Trough Collector Systems. Retrieved from https://www.briangwilliams.us/solar-energy/parabolic-trough-collector-systems.html.

Yahya, W., Nassar, A., Mansur, F. A., Al-Nehari, M., & Alnakhlani, M. (2020). Future Study of Renewable Energy in Libya. *International Journal of Advanced Engineering Research and Science*, 7(10), 1–6.

Zhang, H., Baeyens, J., Degrève, J., & Cacères, G. (2013). Concentrated solar power plants: Review and design methodology. *Renewable and Sustainable Energy Reviews*, 22, 466–481.

Zaroug, M. (2012) Renewable Energy in Libya, ppt presentation, *Renewable Energy Authority of Libya (REAOL),* Wednesday, 28 March, Amman, Jordan.