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Application of Fresnel solar power plant under Algerian climate

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Abstract

The basic resource most important for all the renewable energy potentials is solar energy, it is the radiation emitted in all the directions by the sun. The Fresnel power plant has been chosen to produce the electricity in some Algerian location, for this reason a study takes into account a combination between locations and available resources of the chosen location for having a preferment power plant, than we will optimize the gross output for the same area and turbine using SAM, the results shows that we can reduce the amount of rejected CO₂ up to 87000 tons per year.

"Keywords: Solar Energy;Fresnel power plant; csp,"

1. Introduction

Energy always constituted a vital stake for the man and the human society. The human behaviors are strongly induced by its availability, its abundance or its shortage. From these behaviors will rise from new stakes, in particular for the socio-economic environment and balances. The awakening of the importance of these stakes (climate warming, exhaustion of the resources, increase in the costs of health...) would have, we hope for it, to allow tending towards a more rational use of energy, an optimization of the energy processes which we implement it every day [1]

Because of a world demand of increasing energy, in particular in the field of the building, the even fissile resources of fossil energies are reduced gradually [1]. Thus, the natural gas and crude oil layers will be practically exhausted with more or less long run.

Several work where done in Fresnel power plant [2-9] in this way of research we are going to study the performance of a Fresnel power plant implanted in different Algerian locations (Algiers, Constantine, Hassi Messaoud, Hassi R'Mel), This study will also take into account the reduction of carbon dioxide rejection into atmosphere and its environmental effects .

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2. Chosen Locations

- Algiers** is the capital and largest city of Algeria. According to the 1998 census, the population of the city proper was 1519570 and that of the urban agglomeration was 2135630. In 2009, the population was about 3500000, the site was chosen because we can afford the needed water for the plant from desalination of sea water, the annual insolation data of Algiers are shown in Fig.1 (a).

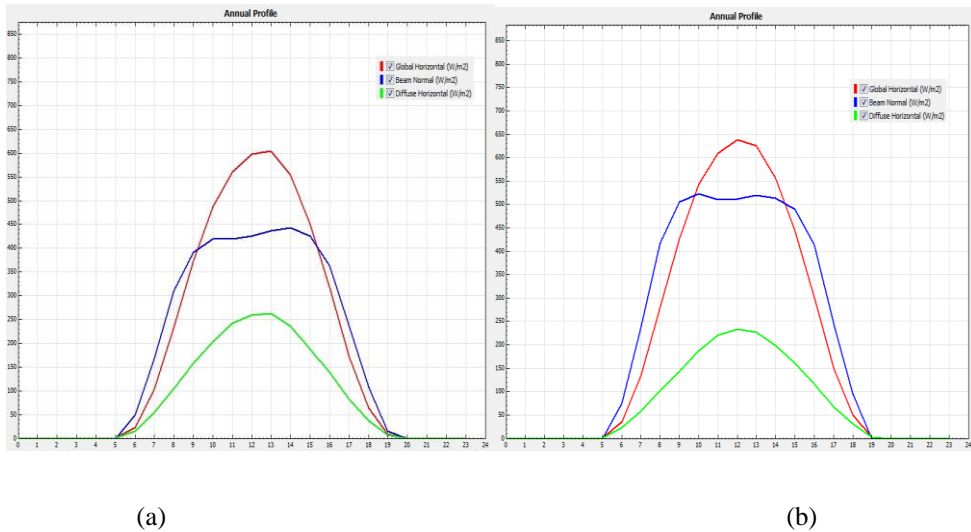


Fig. 1. Annual insolation data of (a) Algiers (b) Constantine

- Constantine** is the capital of Constantine Province in north-eastern Algeria; it is about 80 kilometers from the Mediterranean coast, on the banks of Rhumel river. Regarded as the capital of eastern Algeria and the center of its region, Constantine has a population of 448.37, making it the third largest city in the country after Algiers and Oran, this site is chosen because Constantine is the Capital of eastern Algeria, the annual insolation data of Constantine are shown in Fig.1 (b).
- Hassi Messaoud** is a town in Ouargla province, southeast Algeria, North Africa. Oil was discovered there in 1956 and the town's prominence has grown rapidly since then. It is an oil refinery town named after the first oil well. A water well, dug in 1917, can be found on the airport side of town. It is considered as the First Energy town in Algeria this is why it have been chosen the annual insolation data of Hassi Messaoud are shown in Fig.2(a).

- Hassi R'Mel** is a town in Algeria located near the 18th largest gas field worldwide. Hassi R'Mel is located in Laghouat Province. Hassi R'Mel is a hub for natural gas and oil pipelines running to coastal cities of Arzew, Algiers, and Skikda. In Hassi R'Mel area has an integrated solar combined cycle power station of 150 MW, which thought to be the first of its kind in the world & Algeria, the annual insolation data of Hassi R'mel are shown in Fig.2 (b).

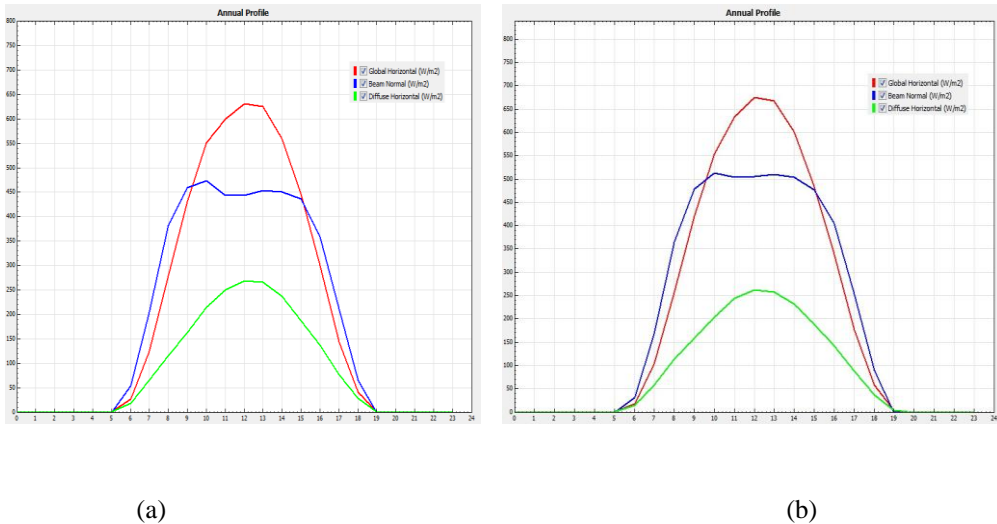


Fig. 2. Annual insolation data of (a) Hassi Messaoud (b) Hassi R'Mel

3. Fresnel power plant

In the Fresnel solar power plant Fig.3, solar energy is used to generate electricity. Sunrays are focused using Fresnel reflectors on to copper tubes filled with water and painted black outside. The water in the tubes then boils and become steam. This steam is used to drive steam turbine, which in turn causes the generator to work.

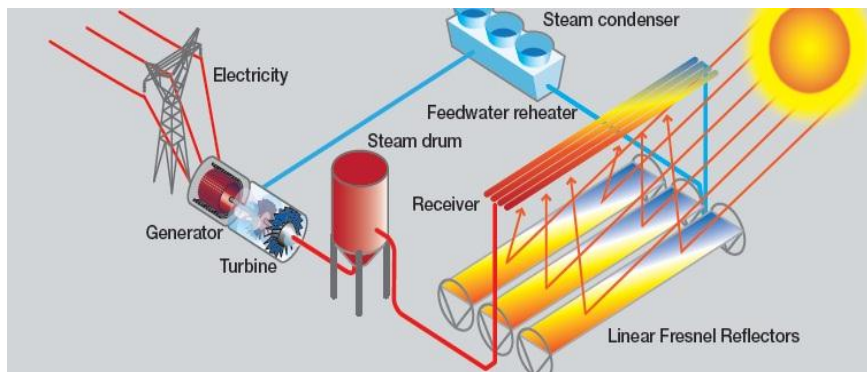


Fig.3 Fresnel power plant scheme

4. System Summary

To have the right to compare the results of simulation, we have done a typical installation for the location, see table 1, the chosen parameters are based on real constructor data.

Note: it's impossible to show all details because of the huge number of components.

Table.1. System summary

components	Value
Solar Field aperture	862848 m ²
Reflective aperture area	513.6 m ²
Length of collector module	44.8 m
Mirror reflectivity	0.935
Design turbine gross output	107 MWe
Gross to net conversion	0.94
Rated cycle efficiency	0.38
Startup time	0.35 hr
Stand by time	2 hr
Condenser type	Evaporative
Tracking power	0.2

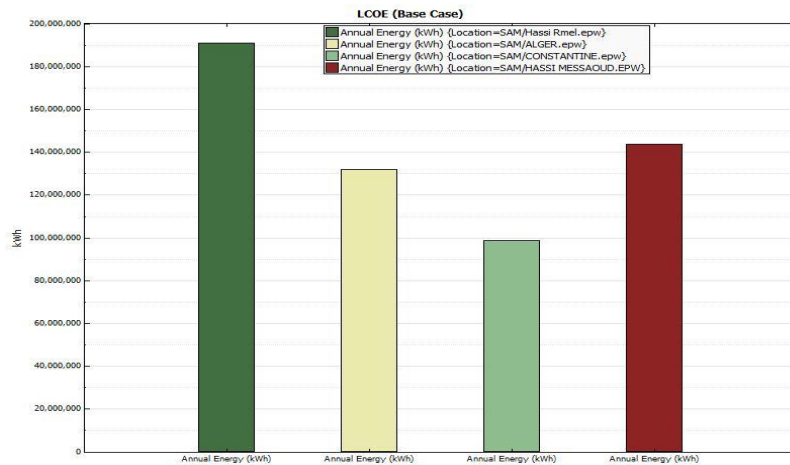


Fig.4 Annual produced energy for different locations

5. Simulation Results

5.1. Parametric simulation for the different locations

The simulation result for the produced energy for each location are shown in Fig.4

- There is a huge difference between the energy produced by each location and the difference could reach 89 000 MWh.
- The best results are obtained by Hassi R'mel location 190 926 MWh of electricity.
- The choice of location has a great influence on the Levelized Cost of Electricity.
- The southern Algeria is the best place to install Solar Thermal power plant

5.2. Water Usage For each location

The simulation result for the produced energy for each location are shown in Fig.5

- The location of Hassi R'Mel uses a huge amount of water 693 307 m³ each year
- The location of Constantine uses 402 985 m³ of water each year
- If we want to produce more electricity we will need more water

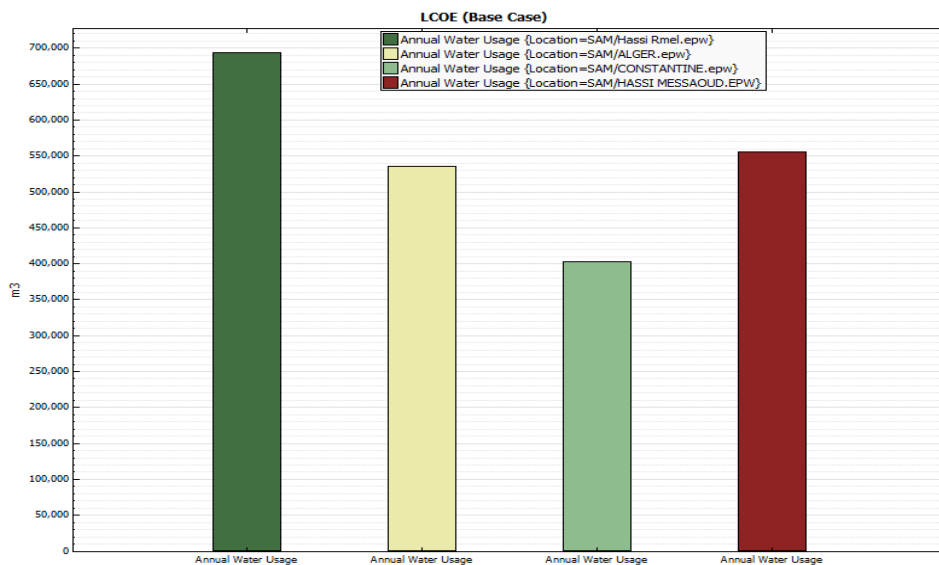


Fig.5. Annual water usage

5.3. Optimization of Gross Output

The chosen solar field aperture can produce more energy for the turbine to extract the most important energy collected from the solar field, see table 2.

Table.2. Optimum values of Design turbine gross output

LOCATION	Design turbine gross output MWe
HASSI R'MEL	125.725
CONSTANTINE	116.924
HASSI MESSAOUD	114.490
ALGER	107.000

The results show that we can produce more energy from the solar field especially for the southern Algerian locations.

5.4. Reduction of Co2 rejection into atmosphere

Carbon dioxide is considered the most undesirable gas who effects our planet and his major role is Earth heating , Kyoto rules implies that we must reduce the amount of rejected CO₂ the table 3 show the reduced amount of CO₂ for each location, this is a comparative study between Gas power Plants and Solar Power plant [10]

Table.3. annual reduction of CO₂

LOCATION	Annual Reduced CO ₂ (Tons)
HASSI R'MEL	87825
CONSTANTINE	45450
HASSI MESSAOUD	45450
ALGER	66172

The results shows that we can reduce the amount of CO₂ in the world using Fresnel power plant the value of reduced carbon dioxide can reach 87000 Tons every year for a power plant with a gross output of 107 MWe.

6. Conclusion

This study shows that it is possible to harness the sun in Algeria to product electricity on a large scale.

- The annual electrical energy produced for a solar thermal power plant of 107 MWe turbine gross outputs and an area of 862848 m² is between 90 000 and 190 000 MWh which is equivalent to the annual consumption of 38 000 homes in Algeria.

- Each plant minimizes the release of carbon dioxide up to 87 000 tons per year (0.46 kg CO₂/kWh).
- The efficiency of the solar thermal power plants is between 13% and 19%.

In the other hand:

- Solar energy is intermittent.
- We must use a lot of water to produce electricity.
- The cost the Fresnel solar thermal power plant is extremely high comparing to Fossil Power Plants

‘we must use renewable energy resources to let our Earth safe for our children and other living creature’

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