HELIOSTAT FIELD DESIGN AND RECEIVER PROFILE ESTIMATION USING OPTICAL RAY TRACING TECHNIQUES

A thesis submitted by

Sanjoy Chatterjee

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Indian Institute of Technology Jodhpur
Department of Physics

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Conclusions and relevant work for future

This thesis has gone into detail study on methods of thermal Solar energy power generation and its harnessing. Solar energy, as a mature avenue of energy generation, made major footprints in global investment which trillion dollars at stake. Among the renewable source of energy, it stands as the fastest growing industry and challenges beating coal, natural gas, and crude oil [65]. Although using the technology and field design mentioned, it is possible to generate healthy electric power but for serious usage in industrial work, higher temperature is necessary. That demands larger Heliostatic fields consisting of thousands of Heliostats and accordingly large investments. In the Indian scenario, especially in the MSME sector, this work may deliver industrial benefit.

For work, Central Receiver System with a set of Heliostats on the ground and the receiver were considered .The work investigated on the multiple possible sets of both the design of Heliostats on the ground and the receiver. The Solar position on the angular basis was done with calculations of Azimuth and Zenith day/hour wise in a precise manner.

Field design pattern on the ground and the receivers were considered and simulated. Radial Staggered (RS) method of field design was performed with multiple sizes of Heliostats and data was compared. Similarly, as the Size of the Heliostats were changed, the receiver were also changed, although not proportionately.

Beyond RS, other method of field setup, for instance, Cornfield and Sunflower was also performed. In the Receiver domain, flat plate, bladed, cylindrical and tubular was performed.

Beam down work has been done with three variants of design namely Inclined Plane, Ellipsoidal surface and Hyperboloid surface.

As the Solar radiation is highly transient, study was done to estimate and optimize by iteration the radiation in the form of rays that may be expected which is important for the industrial way of work.

The work may be continued in future in multiple manner .A set of work may be listed as below.

a. Number of Heliostats on ground to be made more than One thousand : In one of the study, as in the work described in section,181 heliostat (curved and tilted) generates 21 MW of optical power, 40 % of which may be converted to Electrical power. That show 1000 Heliostats (an approximate number, more would be better!) would generate hundreds of MW.

b. Together with Flat receiver, other receivers, which are equivalent or more efficient with less mechanical stress, may be considered.

c. The work to be repeated, if not wholly, partially, with the latitude and longitude of some other geographic location in India.

d. To extend and compare the simulated work with practical field work.

e. To perform the other modes of generation of Solar thermal power.

f. To perform further study on Beam Down optics (with and without CPC) .

g. To increase the generation of temperature for use in the industrial work i.e ~ 2000 K.

h. To use falling particle receiver technology where fluid is replaced by solid particles which lead to an increase in operating temperature thus improving efficiency. Together with that the heat storage capacity of solid particles are reported to be high. These points taken together, lead to high temperature generation and hence lowering the costs of energy storage.[86]

i. To consider the concentration of moonlight.

j. To consider the reduction of Levelized Cost of Energy (LCOE) for Industries in India.

As continues shift between conventional and solar energy supply is not feasible from an industrial logistic perspective [172,173], it is proposed to not only increase the generation of solar thermal energy but also increase/improve storage of the energy so that it may be utilized as per demand, without any disturbance in the generation and distribution system.

6.1 Duck Curve and Levelized Cost Of Electricity (LCOE)

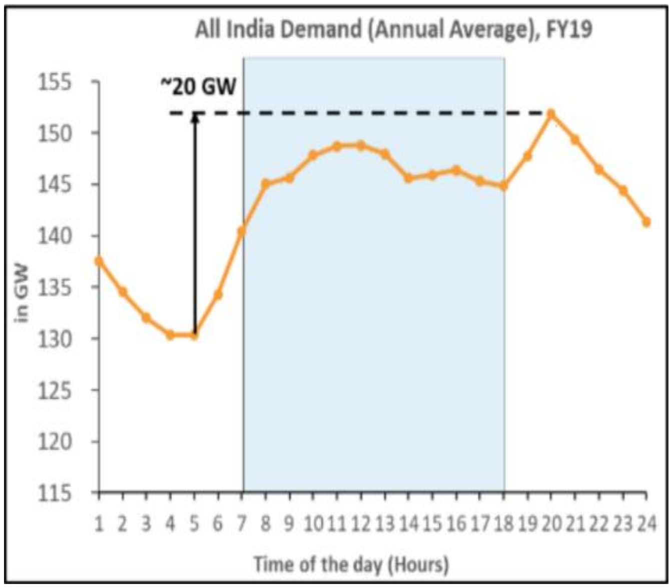

Fig 6.1 Duck Curve and Levelized Cost Of Electricity (LCOE)

India's power demand generally peaks in the evening while the Renewable Energy especially solar energy supply, particularly solar supply peaks around 1200 – 1400 hours period [151,172,173]. This trend will intensify as share of solar capacity in the overall generation mix increases driven by both relative economics and policy push (by 2030, solar is estimated to make 30-35% of total installed capacity as against current less than 10%) [173,174].

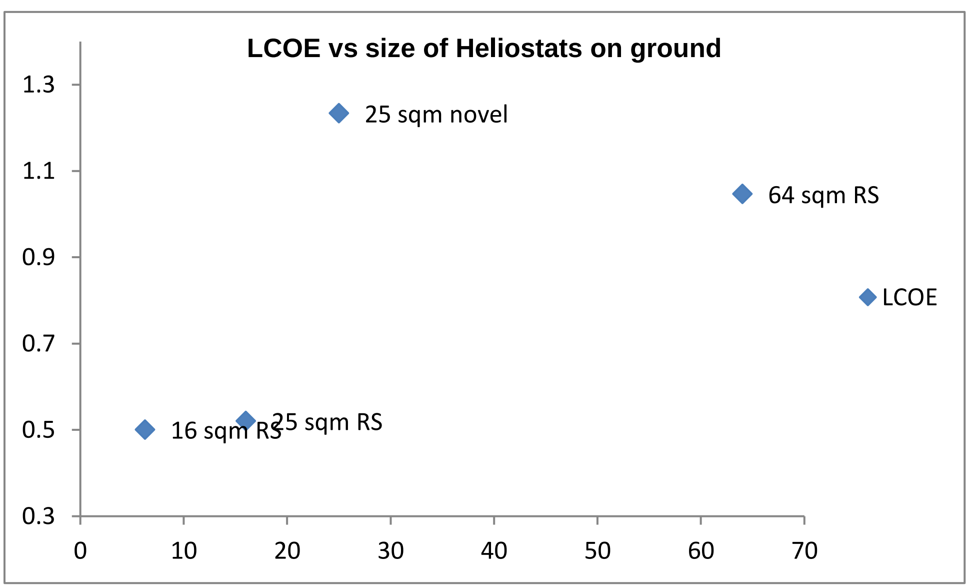

Fig 6.2: LCOE vs size of heliostats on ground

LCOE is a figure of merit for long term measurement used to assess and compare alternative methods of energy production. It is a fundamental calculation used in the preliminary assessment of an energy-producing project. The LCOE may be used to determine whether to move forward with a project or as a means to compare different energy-producing projects.

The formula to calculate the LCOE is $\frac{\text{Net present value of total cost over the lifetime}}{\text{Net Present Value of All Electricity Generated Over the Lifetime}}$

monetary calculation and also the risk calculation [172-174].

$$LCOE^{(2)} = \frac{\sum_{t=1}^{n} \frac{I+M+F}{(1=r)^t}}{\sum_{t=1}^{n} \frac{E}{(1+r)^t}}$$