

Grid Integration of Concentrating Solar Power Plant and Cost Analysis

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ABSTRACT: This paper represents the basic working model of CSP (Concentrating Solar Power Plant) plant. There are different types of CSP plant like PTC (Parabolic Trough Collector) type, LFR (Linear Fresnel Reflector) type, parabolic dish Stirling Engine type, Central receiver type, described with their configuration. After that grid integration of CSP plant simulation is carried out in MATLAB-SIMULINK software. The simulation Results shows that CSP plant grid integration is acceptable. There is a cost analysis of CSP plant and PV plant also described in this paper.

KEYWORDS: Grid Integration, CSP (Concentrating Solar Power Plant) plant, Cost analysis.

I. INTRODUCTION

CONCENTRATING SOLAR POWER (CSP) PLANT:-Concentrating Solar Power (CSP) plants use parabolic trough collector type reflectors to concentrate sun rays onto a Heat Transfer Fluid receiver tube, this heat of the solar radiation is transfers to a working fluid (HTF) like Therminol VP-1 that can be used to produce steam in heat exchanger and steam rotates steam turbine which produce electricity using alternator. Big size CSP plants can be connected with thermal energy storage to allow electricity generation at night duration and cloudy conditions also. CSP plant has four different types:-

1. Parabolic Trough Collector (PTC) type CSP plant
2. Linear Fresnel Reflector (LFR) type CSP plant
3. Central Receiver or Solar Tower type CSP plant
4. Solar Dish Stirling Engine type CSP plant

I) Parabolic Trough Collector (PTC) type CSP plant: - In this type of CSP plant the parabolic trough collector type mirrors are used to concentrate the sun radiation on to the receiver tube which produces heat and this heat used for production of steam in heat exchanger. This steam rotates steam turbine and produce electricity using alternator. The configuration of Parabolic trough collector type CSP plant is shown in fig below:-

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Figure-1: CSP Parabolic Trough Solar Collectors [2]

As shown in fig the parabolic trough collector type CSP plant the parabolic mirrors are 100 meters long with curved aperture of 5-6 meter. The capacity of PTC types CSP plant is near about 14-80MWe. Thermal energy storage using molten salt improves the plant capacity. High temperature molten salt may increase both plant efficiency (e.g. 15%-17%) and thermal storage capacity [2].

II) Linear Fresnel Reflectors (LFR) type CSP plant: - In linear Fresnel reflector (LFR) type CSP plant, an elevated ground facing linear curvature type solar collector are used. The configuration of LFR type CSP plant is shown in fig below:-

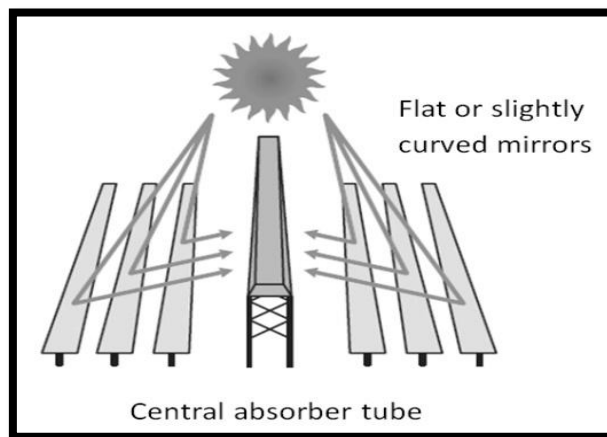


Fig.2- A linear Fresnel reflector systems [2]

The LFR reflectors type CSP plants are same to the PTC type CSP plant. But they are slightly curved mirrors placed at different angles to concentrate solar radiation onto a fixed receiver located some meters above the mirrors. In the receiver tube water is flowing which is converted into steam. Steam is used to rotate the steam turbine and produce electricity.

III) Solar Tower or Central Receiver type CSP plant: - In solar tower type or central receiver type plant configuration is shown in fig. These are large number of heliostats track the sun rays onto the central tower receiver, where the cold molten salt stored. Due to the concentrated solar radiation the cold molten salt is converted into hot molten salt, which produce steam in heat exchanger. This steam is used to rotate the steam turbine and which produce electricity using alternator.

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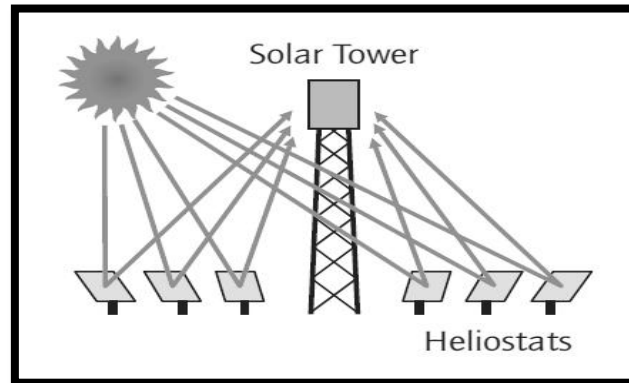


Fig.3- Power tower heliostat assembly [2]

ST plants can be equipped with thermal storage systems whose operating temperatures also depend on the primary heat transfer fluid. Today's best performance is obtained using molten salt at 565°C for either heat transfer or storage purposes. This enables efficient and cheap heat storage and the use of efficient supercritical steam cycles [3].

IV) Dish Stirling engine type CSP plant: - In this type of CSP plant a parabolic dish shaped solar concentrator concentrate the sun radiation onto a receiver, which is placed at the focal point of dish. The configuration of parabolic dish type CSP plant is shown in fig below:-

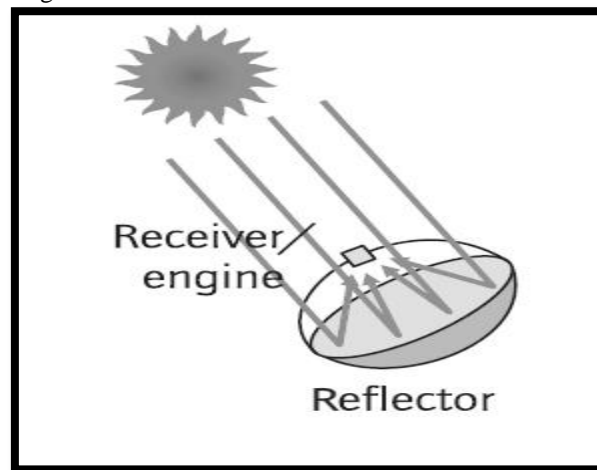


Fig. 4- A parabolic dish reflector focusing sunlight at a point [2]

The heat generated in the receiver is used to drive a Stirling engine that is attached to the receiver. The piston in the system moves in upward and downward direction. This mechanical energy converted into electricity using alternator. Solar dish Stirling Engine type CSP plant is still under Research and Development phase.

II. THERMAL ENERGY STORAGE CONCEPT

The addition of thermal energy storage system in CSP plant improves system efficiency, improves interconnection of CSP plant with grid and also provides continuous power supply to the load. The design and selection of thermal energy storage is so different because of variation in thermal capability of the material used, which should be cooperate with cost effective system design. Some other factors and requirements need to be understand, and from the technical point

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of view, the most important points are: high density in the thermal energy storage material; good heat transfer between the HTF and the storage medium; mechanical and chemical stability of the storage material it means the thermal energy storage material must support several charging & discharging cycles; compatibility between Heat transfer fluid and heat exchanger; complete reversibility and stability in a number of charging & discharging cycles; low thermal losses; and easy of control. And, from the point of view of technology, the most important requirements are: operation strategy; adequate maximum load; appropriate nominal temperature and specific enthalpy drops in load; and integration into the power plant [4].

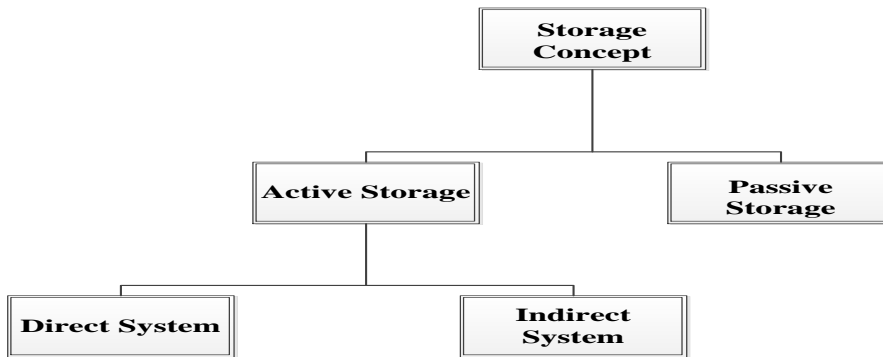


Figure-5 types of TES (thermal storage systems) in CSP plants [4]

There are mainly two types of thermal energy storage system according to their nature: - Active storage system and Passive storage system. An active system is based on thermal transfer through forced convection in the storage material, while a passive system is based in solid materials through which the heat transfer fluid circulates in charging and discharging thermal cycles. Active systems are subdivided into direct and indirect systems. In direct systems, the heat transfer fluid is used also as storage media and on indirect systems a second storage medium is used for storing the heat. A classification of the storage concept is illustrated in Figure-5

III. GRID INTEGRATION OF CSP

When we connect the CSP plant with grid the integration of CSP with grid is shown as fig below:-

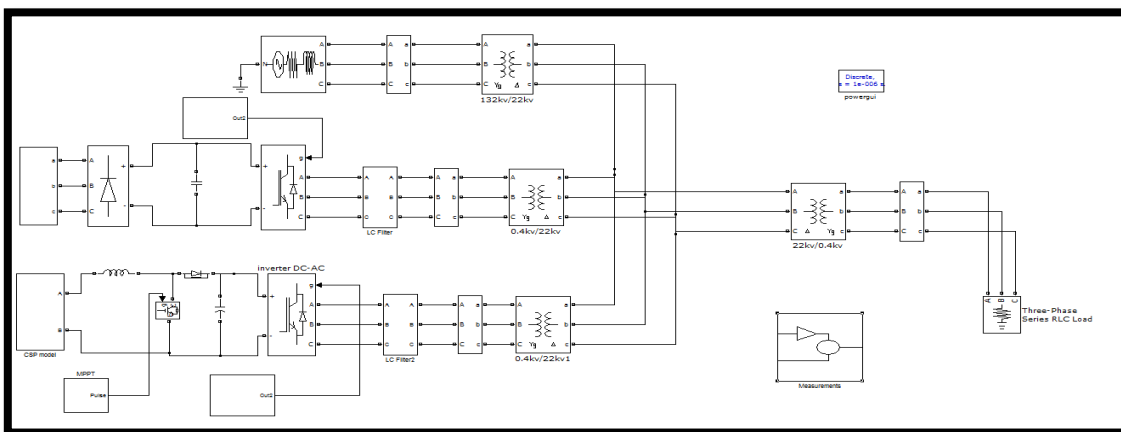


Fig-6-Grid Integration with CSP Plant

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The output values of 3-phase supply like 3-VI measurement, current values are shown in output values. The different parameters of the grid like DC-AC conversion, L-C filter, Switching pulses, 3-phase supply, Maximum power tracking and grid lines are also integrated with the CSP Plant. The Results and output values of currents are shown in fig below:-

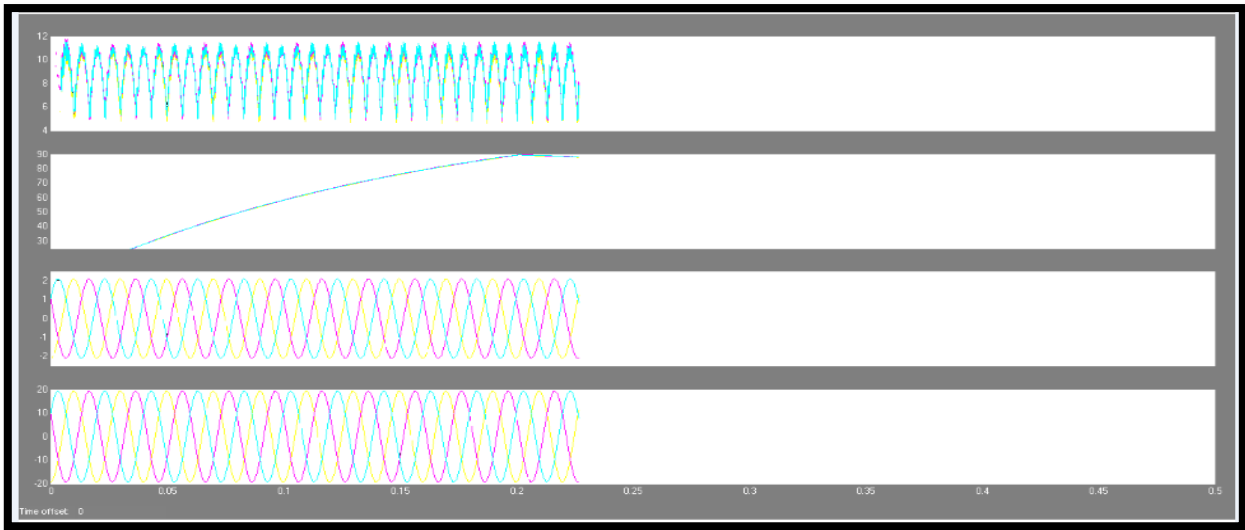


Fig.7- simulation results

The results are shows that grid integration of CSP plant is successful and it is operated in normal conditions. There is no any fault or problems are occurred. So CSP plant performs much better operation compare to PV plant and it is easy to control it.

IV. COST ANALYSIS 1 MWe SOLAR PV PLANT COSTING

Installation cost, total project cost, maintenance cost and also the total & net income from the plant over a year are highlighted below:-

Installation Cost (table-1)

1. Solar panels	
i. German tech.	5.93 cr
ii. China tech.	4.1 cr
2. Central inverters(4)	1 cr
3. Combiner + junction boxes	30 lacs
4. Protective gears arrangment	10 lacs
5. SCADA & Data logger system	10 lacs
6. Land bank	5 lacs (approx.)
7. Erection of project	10 lacs
8. <u>Total project cost</u>	
<u>i. For German Tech.</u>	<u>7.58 cr</u>
<u>ii. For China Tech</u>	<u>5.75 cr</u>

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Table-1 represents the cost analysis of installation of Solar PV plant. The installation cost includes Solar Panels cost, inverter cost, junction box cost, land cost, SCADA and data management system cost, wiring cost, etc. The approximate installation cost of Solar PV plant is near about 6-8 Crore for 1 MWe plant.

Maintenance Cost (table-2)

1. <u>Human resource</u>	20 lacs/ year
2. <u>PV maintenance</u>	1 lacs/ year
3. <u>Site maintenance</u>	1 lacs/ year
4. <u>Total maintenance cost</u>	<u>22 lacs/ year</u>

Table-1 represents the cost analysis of maintenance of Solar PV plant. The site maintenance, PV panel maintenance and cleaning, and other human resources costs are included in the maintenance cost of PV plant. The maintenance cost of 1MWe solar PV plant per year is approximately 22 laces.

Income from the 1 MW solar PV plants (table-3)

1. Daily units generated	<u>5000 units</u>
2. Yearly units generated	5000x365=1,825,000 units
3. Govt. pays per unit (i.e. state electricity board's power purchase rate)	12.5 ₹/ unit (according to WBREDA 2011-12)
4. <u>Total income over the year</u>	2.28 cr
5. <u>net income over the year</u>	2.28-0.22=2.06 cr

1 MWe CSP Plant Costing

In India the capital cost for solar CSP is Rs 12crore per MW as per CERC, 2015-16 guidelines.

V. CONCLUSION

From this paper we can conclude that CSP plant provides electricity during night duration also and we also show that CSP plant grid integration is possible. There are configurations of different types of CSP plant are also described. The simulation results show that grid integration of CSP plant is acceptable. The cost comparison of PV and CSP plant shows that Initial cost of CSP plant compares PV plant is more.

REFERENCES

- [1] Nafisa Noor, Sadid Muneer, "Concentrating Solar Power (CSP) and Its Prospect in Bangladesh".
- [2] Tahsin Faraz Control and Applications Research Group (CARG) Department of EEE, BRAC University, Dhaka, Bangladesh "Benefits of Concentrating Solar Power over Solar Photovoltaic for Power Generation in Bangladesh".



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- [3] Spiru PARASCHIV, Simona Lizica paraschiv, ion v. Ion, nicușor vatachi “Design and sizing characteristics of a solar thermal power plant with cylindrical parabolic concentrators in dobrogea region”.
- [4] O. H. Abdalla, Senior Member, IEEE, R. Al-Badwawi, Senior Member, IEEE, H. Al-Hadi, H. Al-Riyami, Member, IEEE, and A. Al-Nadabi, Member, IEEE, Oct. 1980.
- [5] Keith E. Holbert, Senior Member, IEEE, Colin J. Haverkamp “Impact of Solar Thermal Power Plants on Water Resources and Electricity Costs in the Southwest”.
- [6] Mihir K. Patel, Prof. Alpesh M. Patel, Prof. Bhupendra K. Patel “analysis of concentrating solar power plant in renewable energy sources”.