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ESTABLISHMENT OF LOSS PROFILE MODEL FOR SOLAR POWER PLANTS

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ABSTRACT

A loss profile model is a set of mathematical equations helps to determine losses and its percentage that are occurring in solar power plant. In this paper, different loss model has been introduced for the calculation of losses at every step starting from irradiance (W/m^2) on the module (E_{POA}) till the power output generation. Since solar energy is becoming an important source of energy in India, the losses such as incidence angle modifier factor, temperature loss, soiling factor, cablings losses etc are needs to be studied, on the basis of which solar plant efficiency is judged. With the help of this model we can determine which losses are contributing more losses and which can be further improved.

KEYWORDS: Loss model, E_{POA} IAM factor, Module temperature loss, Soling factor

INTRODUCTION

One of the primary objectives is the study of various losses occurring in 1 MW Solar power plant & to establish Loss Profile Model. This Loss profile model helps to investigate loss percentage at every level in the energy generation process. These models are developed in excel sheets for the different losses referred. Various factors leading to losses such as weather conditions, radiation at site, design parameters of plant and other factors. The latitude 23.22^0 and longitude 72.68^{0}assumed.The tilt angle of pyranometer is 24^0 facing south (Azimuth angle is 180^0 (http://www.pvpmc.org/modeling-steps/)).The information and data required for analysing model are taken from weather station and SCADA system installed in 1 MW Solar power Plant. Thus module design parameters play important role in performance .Losses occurring in plant are the key indication of performance of the plant, best defined by Capacity Utility Factor (CUF) which is the ratio of actual electricity output from the plant to the maximum possible output during the year, which varies over a wide range. Hence we can determine the major loss affecting the output of plant and also can plan strategies to reduce the same losses to improve plant efficiency and performance. It has been studied that Pre-module losses (Tolerance of rated power, Shadow effect, Dust/Soiling losses, Reflection/Incidence Angle Modifier (IAM)) accounts for 10% on an average whereas about 8% in thermal losses and conversion losses and about 14% in system losses (Wiring losses,MPP loss, Inverter loss, Mis-sized inverter loss, transformer loss).

LOSS MODEL AND ASSUMPTIONS

The losses are calculated on the particular day of Summer period(April –June),hence the loss % will be more as compared to other periods as heat losses will be more. Losses are calculated on 8th May, 2014 from 8 A.M to 5 P.M. as values obtained during this period are comparable and measurable. The various angle (azimuth angle, declination angle, zenith angle & angle of incidence) to be used in model are calculated using NOAA calculator (http://www.esrl.noaa.gov/gmd/grad/solcalc) assuming zero error. Loss model starts from the calculation of plane of array E_{POA} (http://www.pvpmc.org/modeling-steps/) .The output from model is compared with the SCADA data and analysed. From this model we'll be able to determine radiation losses on modules with respect to time. After this, with the help of Ashrae Model (http://pvpmc.org/modeling-steps), calculation of reflection losses are done which depends on incident angle. Next model, Faiman module temperature loss model helps to calculate temperature losses due to increase in air temperature, wind velocity and the above mentioned losses. The nominal efficiency of the module is measured at ambient temperature (25^0) but this temperature varies as per the Faiman model, thus efficiency is also affected. The variation of efficiency with respect to above mentioned parameters (temperature coefficient) is proposed by Evans and Florchuetz (1977) Skoplaki E..Before calculation of P_{OUT}, a small experiment was conducted to consider soiling factor because till date no model has been developed for soiling losses. From experiment, we found that Soiling Factor (S.F.) Ryan C.P. *et al.* (1989). is measured as about .954 due to presence of dust. After considering all the above mentioned loss factors P_{OUT} is calculated using Hendrie model (1979) .The P_{OUT} calculated is then measured with SCADA data and the results are mentioned below

RESULTS AND DISCUSSION

From the first model (E_{POA}), the calculated tilted radiations (W/m^2) are compared with the SCADA data, the results are shown in fig-1. From fig-1, we see that model follows linear path before noon but during noon Global Horizontal Irradiance (GHI) become greater than tilted radiations and decreases in evening.

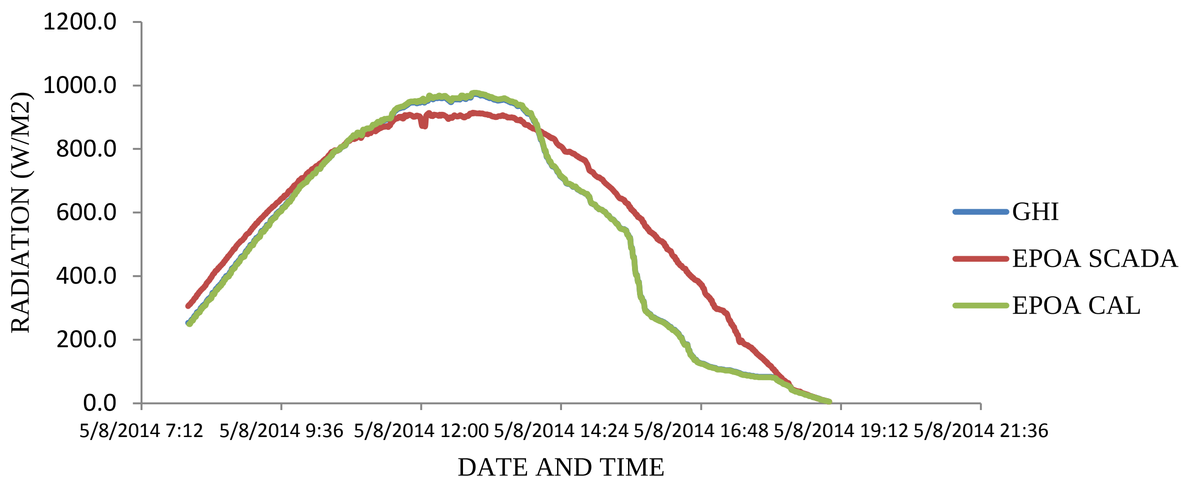

Fig. 1 EPOA SCADA v/s EPOA calculated

From the second model based on ASHRAE model, the Incidence angle losses (IAM) losses are calculated and its effect on E_{POA} are shown in fig-2 From the fig-2, IAM loss factor reduces the tilted radiations to very small extent, but yet to be considered as many softwares like PVsyst assume these losses to be about 0%.

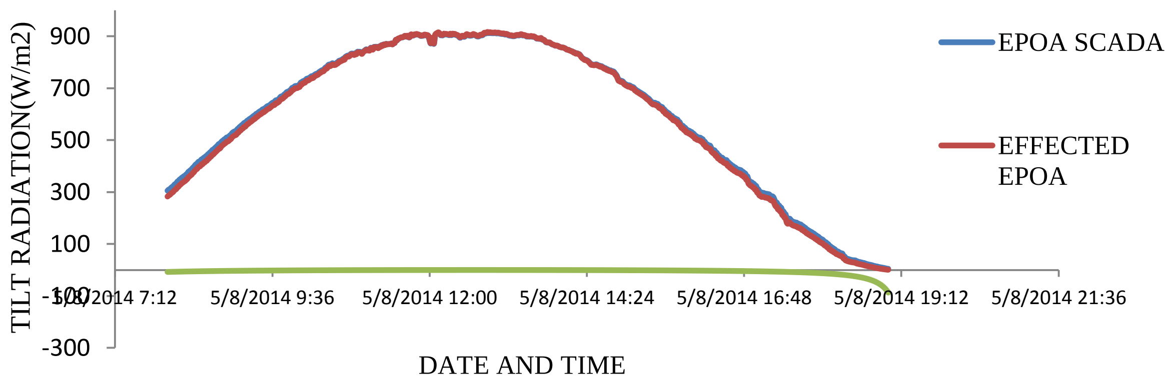

Fig. 2 Effect of IAM factor

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From the third model, Faiman module temperature model, the temperature losses are calculated shown in fig-3. From the fig-3, it is seen that the errors are increasing after 2 P.M.Hence model needs to be verified and the reason (factor) contributing this error.

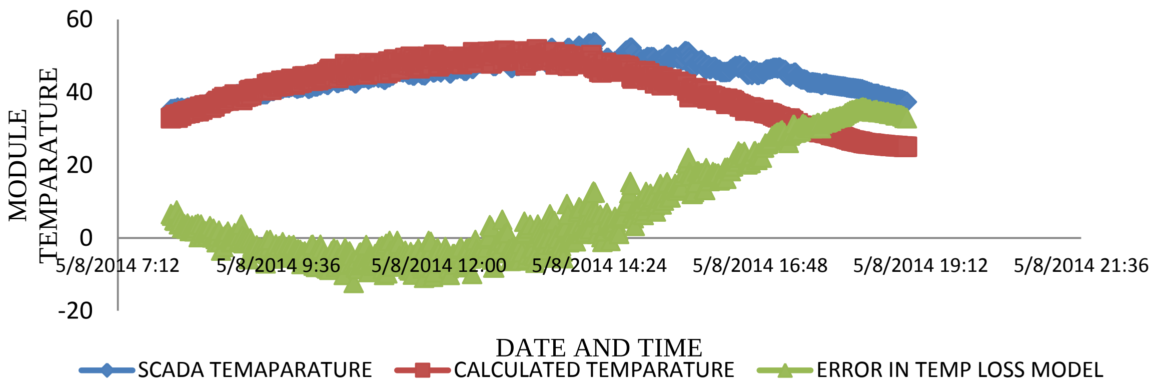

Fig. 3 Variation of module temperature

From the fourth model (Evans & Florchuetz Efficiency model) Ryan C.P. *et al.* (1989).,the variation in efficiency is compared with respect to nominal efficiency .During noon the loss are maximum and reduces before and after noon shown in fig-4.

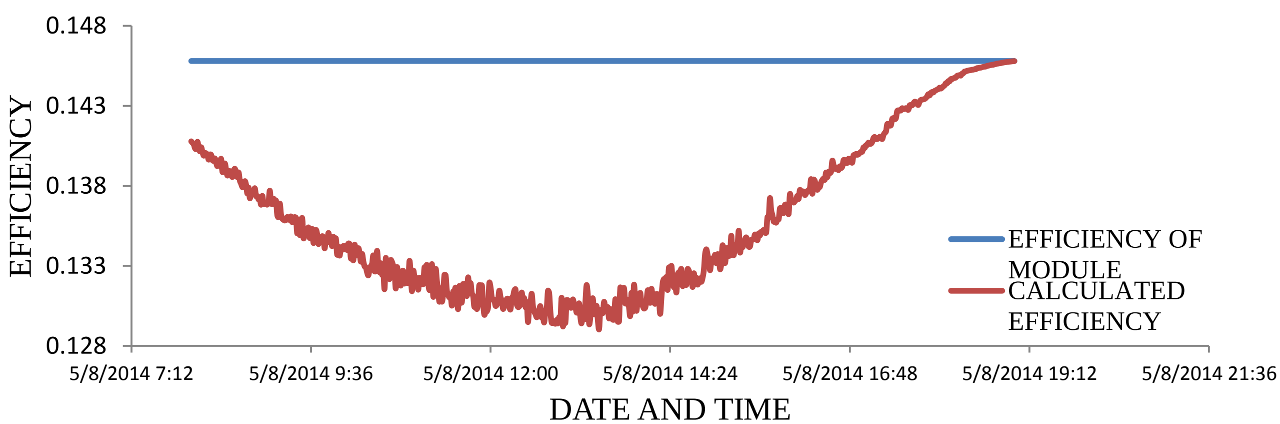

Fig. 4 Variation in efficiency

From fifth model (Hendrie Power output model), the calculated DC power is measured with respect to SCADA power output data, the calculated power out is more when compared to SCADA power output data because P_{OUT} calculated excluding systems losses Solanki Chetan Singh (2011) mentioned above shown in fig-5.

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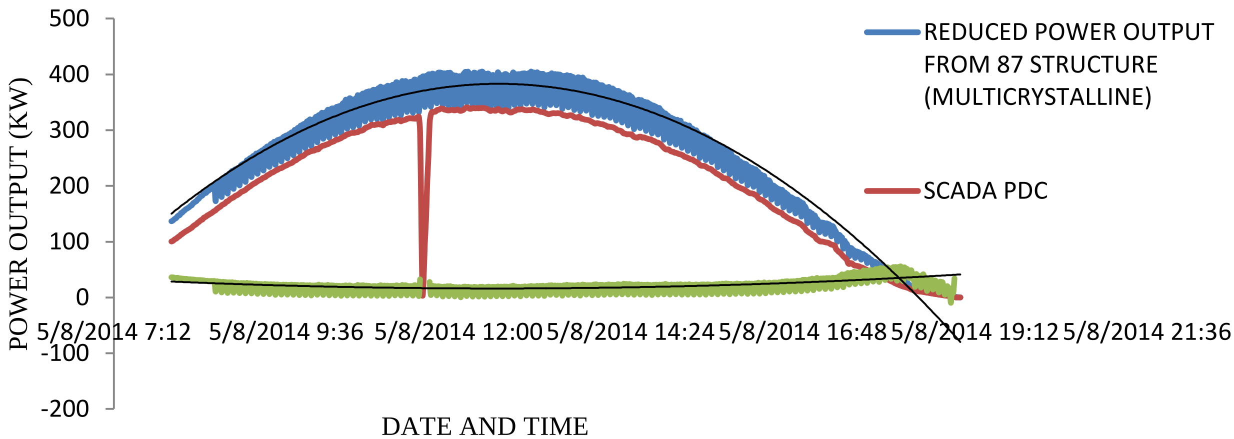

Fig. 5 P_{OUT} SCADA v/s P_{OUT} calculated

CONCLUSION

From the loss model established, it is seen that the E_{POA} (Plane of Array) calculated follows the GHI pattern and gives output higher in noon (12 PM) because sun's height is quiet less during summer period (April to June), hence GHI becomes greater than EPOA SCADA (Special case).From Incidence Angle Modifier, it is found that IAM loss factor varies with time and sun's position. During morning and evening, the losses are maximum about 4% whereas minimum during noon (12 PM) as angle of incidence (AOI) with respect to pyranometer is about 90^0. From Temperature loss mode Rai G.D. (1987), it has been concluded that module temperature greatly depends on air temperature and wind velocity. When the air temperature becomes higher, the module temperature also increases as both are directly proportional to each other whereas when wind velocity increases, the module temperature is reduced due to cooling. There is about 10% errors in model which needs be further improved in future studies. From the Efficiency model , it has been noticed that due to change in module temperature, the module efficiency varies up to 10% which further reduced the power output.The Power output model depends on the various factors like soiling factor, reflectivity, transitivity, plane irradiance (E_{POA}) due to which output reduced to about 25%.Furthermore, soiling model needs to be modelled and other system losses needs to be modelled & AC losses needs to be modelled for complete calculation of losses of plant.

FUTURE SCOPE

Future Scope and expected developments in the field of Loss profile model is precise calculation of losses including weather conditions, locality, region, sun's position and other factors so that it can be followed globally. Loss profile model in solar power plant is expected to play an important role for the calculation of loss at any point and hence to provide proper overcome of loss so as to reduce losses .This proper evaluation of loss helps improve the power plant efficiency & to provide uninterrupted Power supply to the consumers and to reduce equipments and personnel damage/losses in system.

REFERENCES

Rai G.D. (1987). Solar Energy Utilization: A Textbook for Engineering Students.3rd Edition. Khanna Publishers.
Ryan C.P. *et al.*(1989). Solar Cell Arrays: Degradation due to dirt. American section of the International Solar Energy Society, Denver, CO.
Solanki Chetan Singh (2011). Solar Photovoltaic's: Fundamentals, Technologies and Applications. 2nd Edition. PHI Learning Pvt. Ltd.

