Soiling Losses for Different Solar PV technologies in a Rooftop of a Metropolitan City

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Abstract— Soiling is the accumulation of dust on solar panels that causes a decrease in the solar photovoltaic (PV) system's efficiency. The abstract is to show and quantify the soiling losses in a Solar PV Module which affects the generation efficiency. Installation of Solar Rooftop PV System are gaining momentum and its high time we realize how inefficient our PV system if it is not maintained properly. This abstract gives a quantified data of how much losses happen in PV modules due to soiling studied for a month by comparing the difference in generation between cleaned and uncleaned solar modules in a metropolitan city like Bangalore (The study was conducted on the four different types of module technologies installed in a single rooftop of Infosys MNC Building, Bangalore for a period of one month).
Key words: RC Framed Buildings, Soiling

I. INTRODUCTION

Government of India decided to revise the national solar mission target from 20,000 MW to 100,000 MW, among which 40,000 MW is the target for grid-connected rooftop for the next six years. The photovoltaic cells already have low conversion efficiencies in the range of 16% to 20%, the accumulation of sand and dust particles from the outdoor environment on their surface further reduces the generated output power. This is due to the reduction the solar radiation incident on the solar cell. Dust is the lesser acknowledged factor that significantly influences the performance of the PV installations. In polluted environments, over time, they will collect grime and dust. There are also limited field data studies about soiling losses on PV modules. Soiling can be measured as either the rate at which contaminants accumulate on the module surface or the resulting decrease in production. Ultimately, we need to determine the decrease in system performance due to soiling loss. Assuming all other factors remain constant, comparing actual production values between a control subject and a soiled array is one way to determine soiling losses for a given site.

II. OBJECTIVES AND CONDITIONS OF THE STUDY

- To quantify the soiling losses for solar rooftop PV System in a metropolitan city (Bangalore) by analyzing generation pattern between cleaned modules and soiled arrays for a period of one month.
- The uniqueness of this study is the fact that soiling losses is being found out for four different types of solar module technologies (Mono Crystalline, Poly Crystalline, Cd-tel and HIT) erected in a single roof. (First such Project in India)
- The Use of "Solar Edge" inverters and optimizers, where module level online monitoring is possible, helps us in our study of finding out the generation of each module (Be it soiled or Cleaned).
- The modules were not artificially soiled.

III. SITE DETAILS

- Location: Bangalore
- Latitude: 12.9N
- Longitude: 77.4E

Set	Module	No of Modules	Module Efficiency	Inverter
Set-1	Poly - 250 Wp	72	15.90%	SE 17K x 1
Set-2	Mono - 255 Wp	71	15.50%	SE 17K x 1
Set-3	HIT - 240Wp	75	19.40%	SE 17K x 1
Set-4	Thin Film (CdTe) -97.5Wp	186	13.50%	SE 17K x 1

Fig. 1:

IV. METHODOLOGY USED IN THE STUDY

- Four Modules from each technology is left uncleaned as shown in the pictures below.
- Four other Modules in the same array is cleaned as per schedule (Weekly basis)
- Using the Solar Edge Online Monitoring portal, we can get the module level generation data.
- The weighted average of four cleaned modules is compared with the weighted average of four uncleaned modules and the difference in their generation is studied for a period of one month. (Jan 12th to Feb 12th in our case).
- Given below are the results of study conducted in each of the module technology, being shown in the line graph along with the site picture of soiled modules.
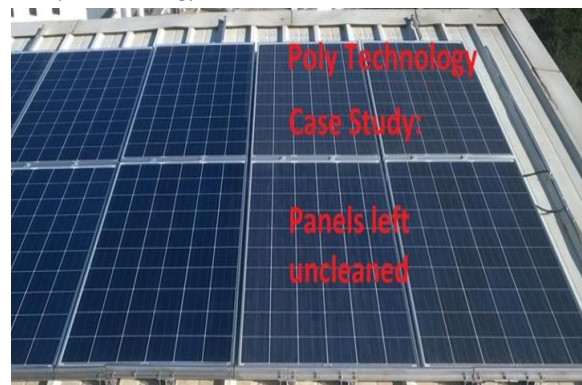
A. Poly Technology

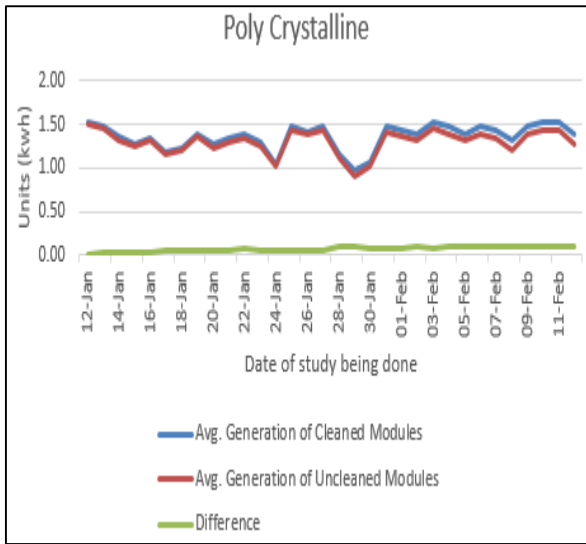Fig. 2: Make: Trina Solar (250Wp per Module)

Fig. 3:

B. HIT Technology
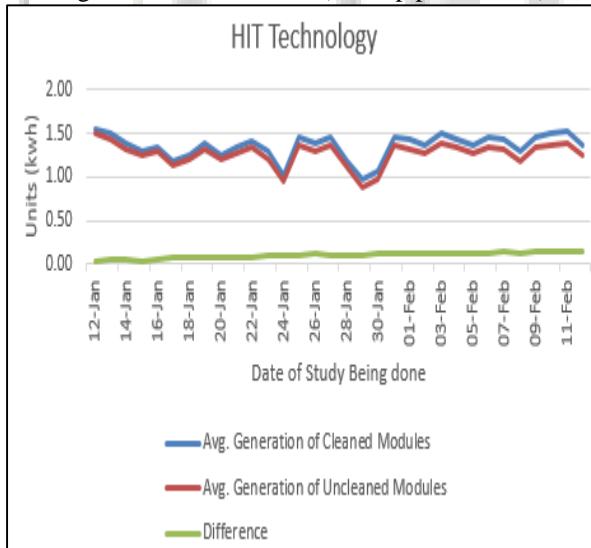

Fig. 4: Make: Panasonic (240Wp per Module)

Fig. 5:

C. Mono Technology
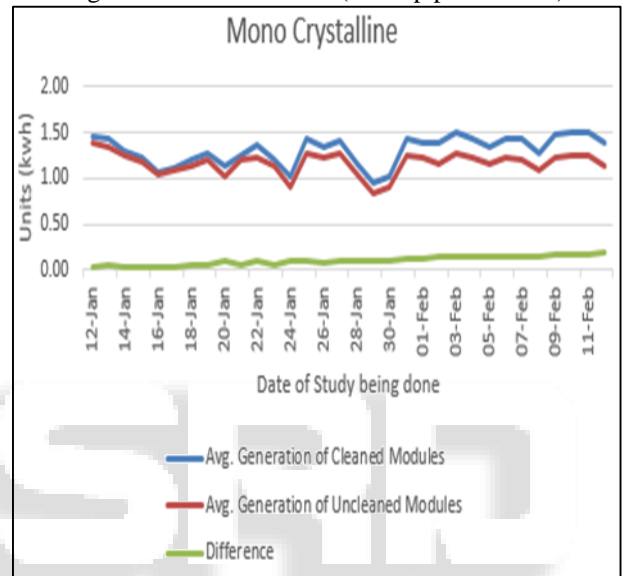

Fig. 6: Make: Shan Solar (255Wp per Module)

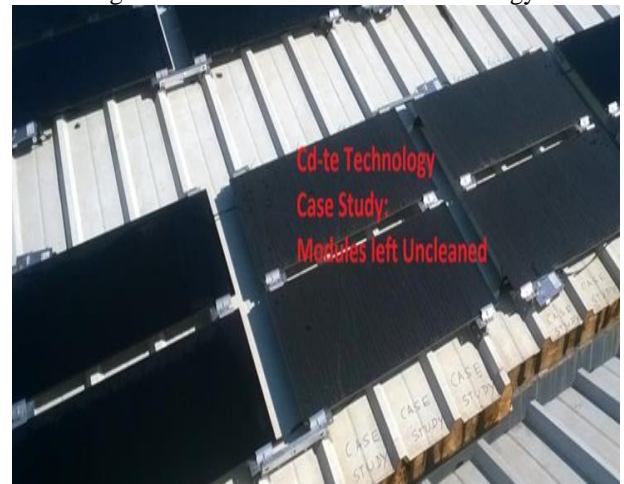Fig. 7: Cadmium – Tellurium Technology:
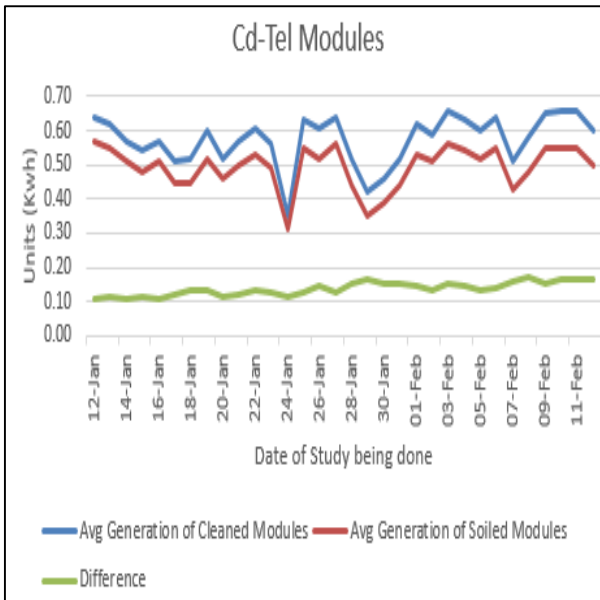

Fig. 8: Make: First Solar (97.5Wp per Module)

Fig. 9:

V. EXPERIMENTAL OUTCOME AND ANALYSIS

After a month long experiment of comparing the generation pattern between cleaned and uncleaned modules across the four different type of modules, we are now able to quantify the soiling losses in Solar PV modules for a month in a metropolitan city like Bangalore where the pollution levels are very high. The results are,

Module Type	Difference in generation (Jan12th)	Difference in generation (Feb 12th)
Mono Crystalline	4%	20%
Poly Crystalline	1%	17%
HIT	3%	21%
Cd-Tel	9%	22%

Table – 1:

As given in the table above, we can see a **20% change in generation** (Average difference in generation between cleaned and uncleaned modules)
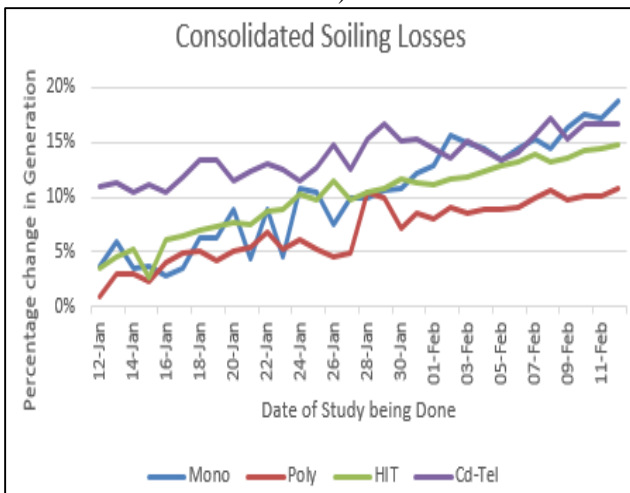

Fig. 10:

VI. CONCLUSIONS

Soiling losses is a big concern while evaluating performance of a PV system, there are different research conclusion based on laboratory data. But there are very few studies which are done on the actual site. This study concludes the soiling losses on different PV technologies installed specifically on a roof in a metropolitan area where dust contents are extremely different thus causing different refraction indices. The PV technologies subjected to this study includes poly-crystalline, mono-crystalline, Hetero junction Intrinsic thin film (HIT) and Cd-Te Thin film. The one-month data recorded in this study has indeed given a direction for PV Fraternity round the globe to evaluate the soiling losses and re-think on the conventional figures to be considered till date. The main purpose of this study was to see what exactly are the dust contents in any metropolitan area and how they are affecting the decrement in energy generation at the same time in different technologies.

REFERENCES

[1] C. P. Ryan, F. Vignola, and D. K. McDaniels, "Solar Cell Arrays: Degradation Due to Dirt," in Proceedings of the American Section of the International Solar Energy Society, Denver, CO, 1989, pp.234–237.

[2] T. U. Townsend and P. A. Hutchinson, "Soiling Analysis at PVUSA," in Proceedings of ASES-2000,Madison, WI, 2000.

[3] A. Kimber, L. Mitchell, S. Nogradi, and H. Wenger, "The Effect of Soiling on Large Grid-Connected Photovoltaic Systems in California and the Southwest Region of the United States," in Conference Record of the 2006 IEEE 4th World Conference on Photovoltaic Energy Conversion, Waikoloa, HI,2006.

[4] J. R. Caron and B. Littmann, "Direct Monitoring of Energy Lost Due to Soiling on First Solar Modulesin California," in Proceedings of the 38th IEEE Photovoltaic Specialists Conference, Austin, TX, 2012.

[5] H. Qasem, T. R. Betts, H. Müllejans, H. AlBusairi, and R. Gottschalg, "Effect of Dust Shading on Photovoltaic Modules," in Proceedings of the 27th EU PVSEC, Frankfurt, Germany, 2011.

[6] J. Zorrilla-Casanova, M. Piliougine, J. Carretero, P. Bernaola-Galván, P. Carpena, L. Mora-López, andM. Sidrach-de-Cardona, "Losses produced by soiling in the incoming radiation to photovoltaicmodules," Progress in Photovoltaics: Research and Applications, p. n/a–n/a, Feb. 2012.

[7] J. Zorrilla-Casanova, M. Piliougine, J. Carretero, P. Bernaola, P. Carpena, L. Mora-López, and M.Sidrach-de-Cardona, "Analysis of Dust Losses in Photovoltaic Modules," in Proceedings of the WorldRenewable Energy Congress 2011, Linkpoing, Sweden, 2011.

[8] M. Alonso-Garcia, J. Ruiz, and F. Chenlo, "Experimental study of mismatch and shading effects in the I-V characteristic of a photovoltaic module," Solar

Energy Materials and Solar Cells, vol. 90, no. 3, pp. 329–340, Feb. 2006.

[9] A. Driesse and B. Harris, "Non-Uniform Conditions and Performance in Parallel-Only and Series/Parallel Array Configurations," presented at the 25th European Photovoltaic Solar Energy Conference, Valencia, Spain, 2010

[10] Marcus, A., Semantic Driven Program Analysis, Kent State University, Kent, OH, USA, Doctoral Thesis, 2003.

[11] Marcus, A. and Maletic, J. I., "Recovering Documentation-to-Source-Code Traceability Links using Latent Semantic Indexing", in Proceedings 25th IEEE/ACM International Conference on Software Engineering (ICSE'03), Portland, OR, May 3-10 2003, pp. 125-137.

[12] Salton, G., Automatic Text Processing: The Transformation, Analysis and Retrieval of Information by Computer, Addison-Wesley, 1989.

[13] Soiling Losses of Utility-Scale PV Systems in Hot-Dry Desert Climates:Results from 4-16 Years Old Power Plants, NREL, 2012

[14] Soiling and Dust Impact on the Efficiency and the Maximum Power Point in the Photovoltaic Modules

[15] E. Suresh Kumar#1, Dr. Bijan Sarkar#2, D.K. Behera#3, Kolkata, February-2003