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Sustainable Engineering Worldwide

As-Built Energy Yield Assessments – A Risk Mitigation Approach

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1 Introduction – As-Built Energy Yield

With solar PV having emerged as the leading technology in the renewable energy sector, with over 480GW global installations, the need for continual development and advancement in the methodologies for assessing the long-term profitability of the technology play a crucial role in the progress of the industry.

One of the primary mechanisms adopted to ensure the same is through accurately predicting the power generation of a solar power plant through detail oriented energy yield estimations. These estimations take into account various technical factors affecting a project and thereby predict the resultant yield that can be expected for a particular time period. It is therefore crucial that the energy assessment accurately represents the working of a solar PV plant thereby incorporating precise losses incurred on site.

The current market trends indicate the use of the energy yield assessments conducted at the feasibility study stage of a solar PV power project to be adopted within the financial model employed by many lenders and financial institutions. These solar PV plant energy yield assessments capture various aspects of the project that are envisaged during the inception stages of the project. However, considerable variations arise in the project design subsequent to the conceptual development of the PV plant i.e. during the detailed design and engineering, and over the course of the construction phase of the project.

These variations are often overlooked by many solar power consultants and solar PV plant developers in evaluating a precise energy yield model after the commissioning of the project. Exclusion of these design deviations arising between the initial assessment and the final project design implemented at the project site may have considerable impact on the accuracy of the yield predictions for any given site. *As a result of these deviations, the project finance analysis may also be adversely affected, thereby posing as a risk to the lenders and in turn the annual revenues of the project.* The decision to proceed with the development of a solar PV project rests upon the commercial viability of the project, as determined through a financial assessment. SgurrEnergy India has described various such avenues that are the prevailing factors, wherein the PV plant is not accurately modelled in the assessment.

Based on the cumulative experience of SgurrEnergy in conducting project planning and solar PV power plant feasibility studies in the early stages of plant conceptualisation, in conjunction with detailed engineering and designing of the PV projects for over 20GW, SEI intends to initiate evaluating projects based on finalised design and conducting a corresponding predictive yield modelling of the project, or in-short, an '*As-Built Energy Yield Assessment*'.

The as-built assessments can cater to lenders and various financial institutions for them to evaluate with higher confidence the financial aspects of a given project.

In the article, the loss assumptions that can vary over the course of the project design have been enlisted in order to provide clarity on the extent of their impact on the yield estimations and thereby the significance of considering them within an as-built energy yield estimation of the project.

2 Investigating the Variations

In a typical energy yield for a solar PV project, several losses affect the annual power generation. However, among these losses, the following are the common variations observed in the project planning and the operational phase by SgurrEnergy. These deviations are based on the observations made over the course of project planning up until commissioning.

2.1 Inter-Row Shading Effects

Inter-row shading loss essentially depends on the land terrain, slopes and topography. ***Often neglected due to non-availability of topographic surveys in the feasibility / early stages of project***, this shading loss may pose a major hindrance in arriving at an optimum yield. If not included in an energy prediction model, an overestimated figure is produced of the project's performance.

Analysis of inter-row shading impact typically requires the topography studies of the site, and as per the final solar PV plant layout, PV arrays are manually modelled in the simulation. Substantial energy loss can arise due to negligent levelling and grading of unwanted elevated land parcels.

Figure 2-1 illustrates an indicative schematic on the variation in ground slopes; whereas Figure 2-2 provides a graphical representation of the monthly shading loss for a typical PV array due to inter-row shading at varying slope levels.

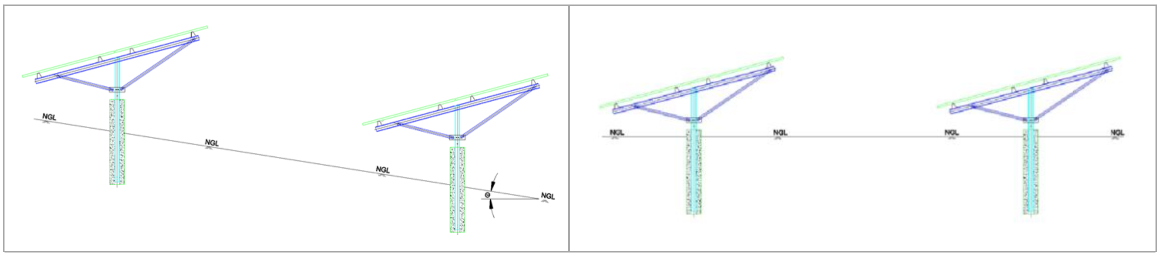

Figure 2-1: Indicative Schematic of Variation in Ground Slopes

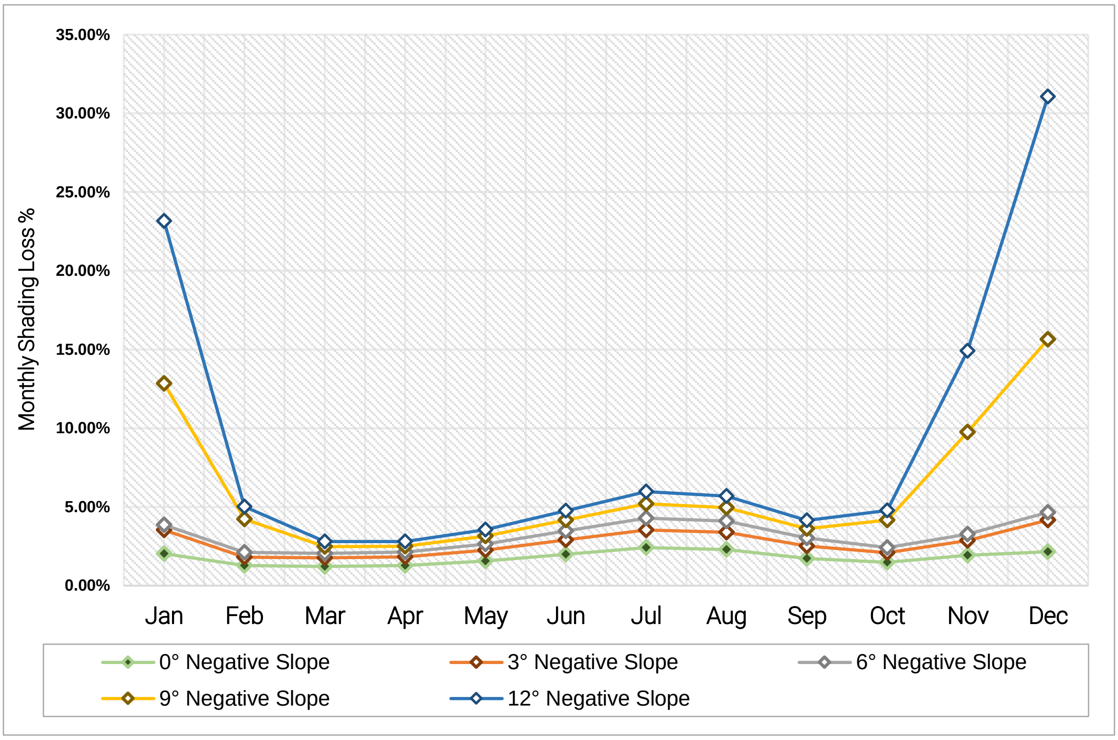

Figure 2-2: Monthly Shading Loss for PV arrays at different Ground Slopes

2.2 Shading due to Obstacles

It is a general practice during design and installation, to avoid shading on PV arrays due to nearby obstructions that include PV plant equipment and environmental obstacles such as hillocks, trees etc. The PV projects' in situ structures include inverter stations, control rooms, lightning arrestors, transmission towers, fencings etc., whereas environmental obstacles include trees, minor hillocks and various other obstructions.

These obstacles are often not-considered within the modelling of the project and thereby also resulting in the miscalculation of the respective PV arrays.

2.3 PV Module Performance

Subsequent to the shipment of the PV modules the manufacturers provide flash test reports indicating the various parameters that affect the performance of the PV module. ***These reports depict the deviation of the module performance with respect to its actual rated capacity***; and therefore, these values play a major role in characterising the PV performance on a string and system level.

Modern modules tend to have a positive tolerance with respect to their rated capacities; and the flash tests, once evaluated, give an accurate performance prediction of modules with respect to module quality gain/loss corresponding to its nameplate capacity and module mismatch occurring at site.

2.4 Angular Losses

The sun path varies over a day resulting in change in irradiation falling on the PV array. A PV plant exhibits maximum yield when the sun is perpendicular to the plane of array; however, during the course of the day when the sun is not perpendicular, there is a reduction in total irradiation reaching the plane of PV array, specifically the direct beam irradiation.

Sunlight enters the module through the glass and encapsulant, which serve as an enclosure to provide adhesion between solar cells and mechanical robustness to the modules. By default, the properties of these materials should incorporate high light-transmissivity in order to avoid losses in radiation transmission. This is primarily quantified by the Incidence Angle Modifier (IAM) profile of the module, and is calculated based on the physical parameters of the module materials.

This profile, is developed by the module manufacturer and verified by an independent laboratory tests. Generally subsequent to the commissioning of the modules, the manufacturer provides an independent laboratory test accurately predicting the angular losses occurring in the module resulting in an un-biased loss value.

2.5 Ohmic Loss Evaluation

During the project-planning phase of a project, due to incomplete land acquisition, the layouts of the proposed solar PV plant are not finalised, thereby leading to various assumptions on array placement and consequently, rudimentary ohmic wiring loss assumptions.

However, during the execution phase of the project, subsequent complete land acquisition and finalised design, the cable routes are optimally developed thereby resulting in an ohmic wiring loss calculation, deviating than the initially assumed value.

It is evident that with an increase in the length of a cable, a corresponding increase in loss is observed, therefore it is essential to encompass the modified cable losses calculated during the detail designing phase.

The estimation obtained as a result of using the assumed loss values tends to lead to over or underestimated values which is considered to be an improper engineering practise, and must therefore be revised on inclusion in the as-built energy yield estimation.

3 Conclusion

Based on the discussions above, the variation in the estimation of the energy yield values can be considerably large due to incorporation of the above mentioned assumptions of the losses and thereby can have a significant impact on the accuracy of predictions. As stated earlier, this can crucially affect the profitability of the solar PV power plant.

Figure 3-1 illustrates the extent in deviation of loss values over the course of project development.

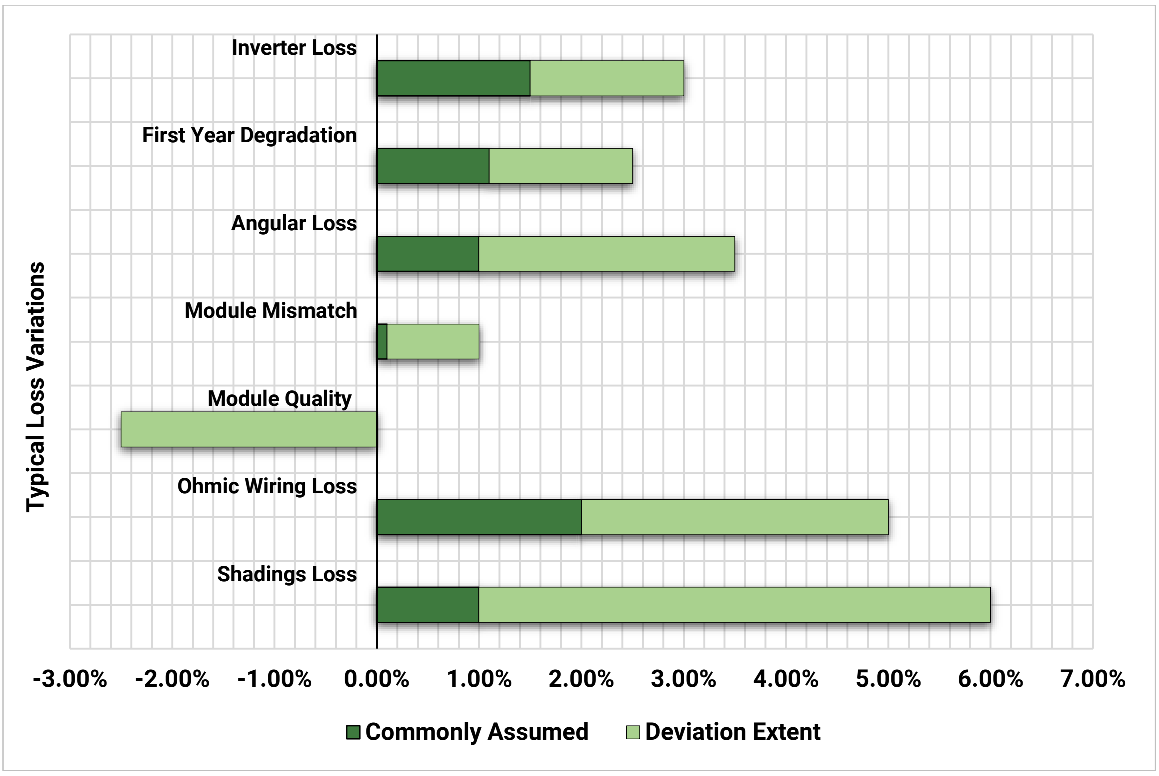

Figure 3-1: Extent of Deviation Loss Values

In order to reduce the possibility of inaccurate estimations resulting from standard/generic assumptions, it is of utmost importance that the project be modelled in the most representative way to capture the imperative characteristics of the PV project.

The as-built energy yield predictions can help in providing crucial information that may have been overlooked in the earlier stages of the project, therefore providing a better understanding of the PV plant performance and also aiding in the anticipation of the various prospects for optimization of the project.

In situations where the assessment had not been carried out for the project, the same can nevertheless be carried out at a subsequent stage of plant operation for the purpose of refinancing or other financial calculations to be assessed during the operation of the PV plant.

SgurrEnergy therefore advocates the use of the as-built energy yield estimations towards the final stages of the PV project, for the sole purpose of risk mitigation and reducing liabilities of the PV project.