Optimizer-based PV systems under shading conditions

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Introduction

Recent decrease in the cost of photovoltaic (PV) panels [1] and the increased average residential PV size in Sweden [2] has caused larger residential roof-top PV installations to become more popular. This implies they might be mounted on roof segments with different orientation. Additionally, with larger installation size the likelihood of having partial shading increases. Thus it is expectable to have varying irradiation conditions on different parts of the PV system.

Total or partial shading conditions (PSC) have a detrimental impact on the output energy of PV systems. Shade causes a reduction of the power delivered. Traditional string PV systems work with one or two central Maximum Power Point Tracking (MPPT) for the entire system, which means that when they undergo PSC, the overall system's production is limited by the solar panel providing the minimum output.

An effective solution to mitigate the shading effect is the use of power optimizers. These devices act at module level with the individual MPPT's, which leads to better PV system performance in comparison to a string-based system [3]. The electrical configuration of both systems is shown in Figure 1.

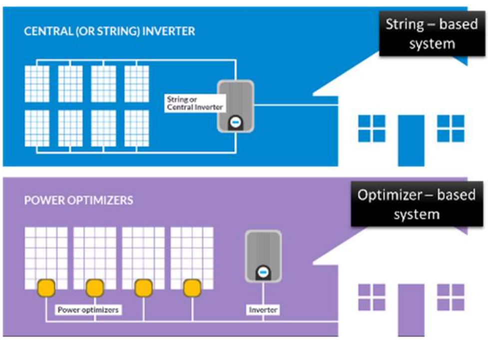


Figure 1: String-based PV system with central MPPT for entire system and optimizer-based PV system with individual MPPT for each panel

Procedure

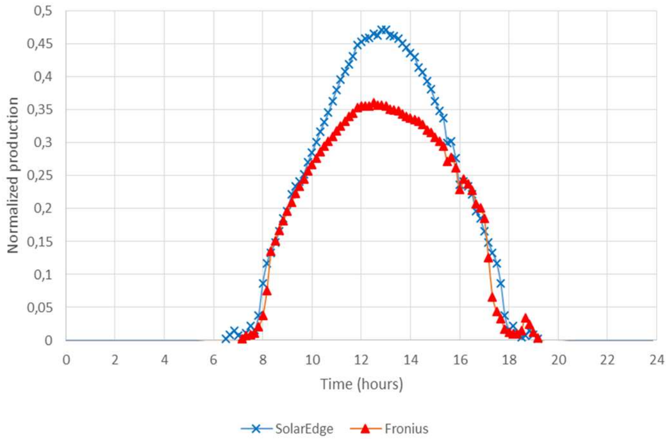
To quantify the gains with power optimizers, measurements and experimental setups were carried out at Vattenfall laboratory (Sweden) to investigate production gains under shading conditions that are realistic for small homes. This study evaluates the performance of two PV systems with different power conversion setups: a 3.3 kW_p PV array from 2017 connected to a Fronius string inverter and a 2018 4.3 kW_p array connected with SolarEdge optimizers and inverter. The solar panels are of compatible STC ratings. Experiments were performed to verify the optimal orientation of the arrays and their performance under simulated snow coverage and tree shading.

The PV production of both systems was measured for East and South orientation to verify their optimal configuration. The simulated snow coverage experiment used semi-transparent mesh attached to the bottom row of both systems covering up to 60% of each module (*Figure 2*). With the aim to recreate a more realistic shading pattern a pine tree is placed directly south of the arrays (*Figure 2*), simulating the shade projected by neighboring trees on residential PV installations.

Figure 2: Experimental setup with simulated snow coverage (left) and for the tree shading experiment (right)

Results and conclusion

Findings demonstrated that the output achieved with South orientation was 30-36% higher than East-oriented. Shading losses with optimisers were reduced from 50% to 29% on clear May days when simulated snow coverage is applied (*Figure 3*). Results also showed that optimizers decreased tree shading losses from 24% to 9% with differing irradiance over two weeks in June (*Figure 3*). This full measurement period of two weeks with varying cloud coverage confirmed that these gains are obtained also under longer periods.



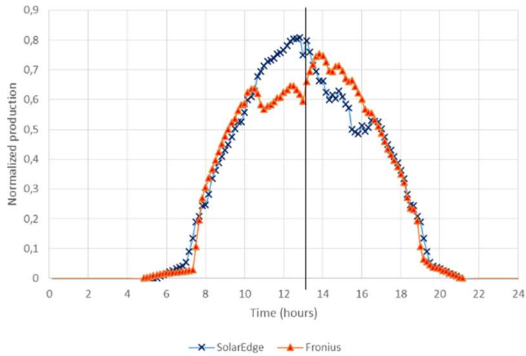


Figure 3: Normalized production of both systems under fabric mesh shading (left) and tree shading (right)

References

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