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SolarEdge Yield Advantage- White Paper

Introduction

The SolarEdge DC Optimsed Solar PV configuration is a state-of-the-art system designed to harvest the maximum possible energy from photovoltaic (PV) modules in grid-interactive (grid-tied) PV systems. A SolarEdge DC Optimsed PV system consists of three main elements: PV modules, power optimisers (DC to DC converters) located at each module, and a separate DC to AC grid-interactive inverter which can be located at the array or at a remote location, e.g. near the main switchboard.

The SolarEdge system topology when compared with a traditional string system offers many advantages from the perspective of yield and energy harvesting, primarily due to the fact that the system offers an MPPT per module (or per two modules in commercial systems) when compared with a traditional string inverter system that can only offer an MPPT per string. In addition, the DC to AC conversion process of the SolarEdge topology offers a fixed DC voltage that enables the inverter to remain within its peak conversion efficiency throughout the production window whereas a traditional string inverter will only offer a variable range of efficiencies depending upon the V/.I characteristics of the MPPT output.

SolarEdge systems generated 5.95% more yield, from actual installations throughout Australia, (from over 500 randomly selected sites) when we compared the PV module IV curve modelling of traditional multi MPPT string inverter systems using modelling values, losses and efficiencies taken from PVsyst. When compared to a single MPPT traditional string inverter, the additional yield value was >9%.

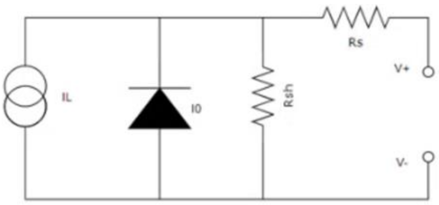
This white paper describes the process and findings of recent SolarEdge studies to assess the additional yield, additional energy, that a DC optimised system can deliver versus a traditional string-based system.

Modelling

To be able to accurately create a yield comparison between a DC optimised SolarEdge system and a traditional string inverter system we had to create a model whereby we could verify that the input characteristics of the PV module (string) were the same.

Using the one diode model we applied the following implicit formula whereby we can take the R_s shunt and R_{sh} shunt resistance value from the metadata of our system telemetry. The other main components of the equation, being I (current) and V (voltage) we can also obtain from module data. I_L and I_0 values needed to be assessed.

With only knowing the primary functional values, however, we can still assess and generate an accurate representation of the IV curve of the panel.



$$I(V) = I_L - I_0\left(e^{\frac{q(V-IR_s)}{n_s \gamma k_B T}} - 1\right) - \frac{V - IR_s}{R_{sh}}$$

I: total panel current
V: total panel voltage

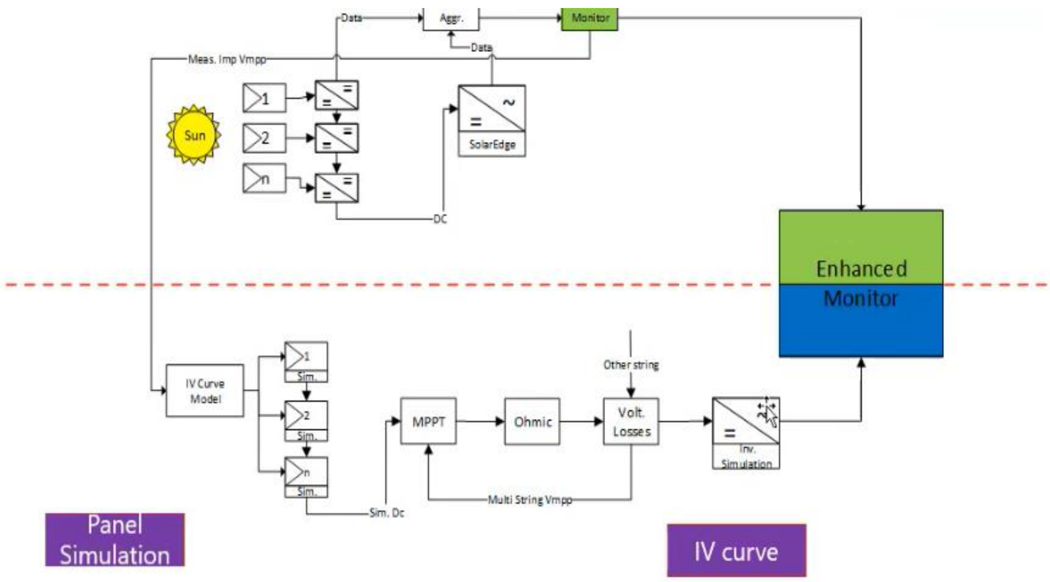
I_L: light genrated current
I_0: Dark saturation current

n_s: number of cells in series
γ: diode ideality
T: cell Temperature [~stc]
R_s: series Resistance
R_{sh}: shunt Resistance

In order to assess the values and simulate what the characteristics are of the total IV curve in a string inverter, individual panel IV curves are summed together in series, applying an ideal bypass diode.

In a SolarEdge DC optimised string however, we can very simply measure with our optimisers a lot of prerequisite values. This data, which is transmitted to the inverter, and the inverter then sends this data to our monitoring is fully accessible, so we know how much our site produced.

Once the string IV curve is estimated, an ideal MPPT is applied to simulate the string's yield in the absence of panel-level optimisers.



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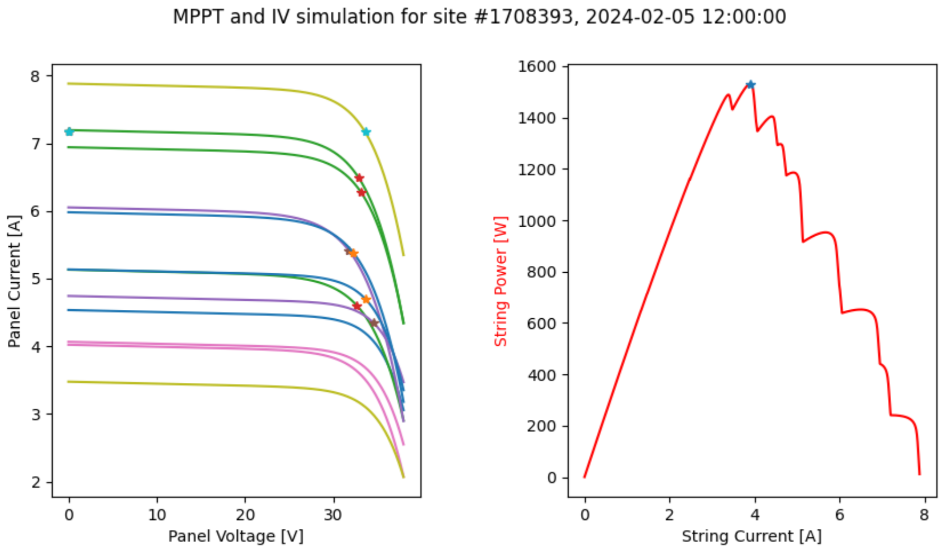
In this modelling, for both a DC optisimed and traditional string system, we focused on one string, and one inverter.

By applying the formula, the modelling, as expected, has the ability to generate a lot of minimal, and maximal values as it is building from a multitude of different type curves from a volume of different PV modules.

In an idealized scenario, if everything was equal, the IV curve would look as though it was aggregated and would be smooth, but due to small mismatch values at a cell and module level, the actual string output is always more complicated, and you will see multiple IV curves per string.



In real-life situations, the IV curve is not static. To address this, the process of string IV curve assessment takes place for every telemetry, accounting for the variable field conditions.

SolarEdge optimisers provide one point on the IV curve by measuring the instantaneous panel voltage and current. If the system is not in over power, we can assume that this point is also the panel's MPP. These two constraints allow us to find the missing parameters in the 1-diode model, and obtain the IV curve

From this we could then assess that this will equal down to zero point, it will then allow us to be able to represent P of V through this equation. In cases where the system is in over power, as reported by the inverter telemetries, we conservatively ignore the estimation process and set the mismatch to 0.

By assessing the IV curve for any certain optimiser, we are able to also assess it for all optimisers within the string. With the IV curves calculated, we could answer two questions:

1. By applying the IV modelling of each module we can simulate the output of a SolarEdge system.

2. By applying the IV modelling of the aggregated sum of all of the modules we can model what will happen if we had only one MPPT as per a single MPPT input of a traditional string inverter.

    a. There is bias in this module as it is assuming that each module within the traditional string system has the ability to be able to produce all power at the maximum MPPT for the given IV curve.

    b. To generate more comparable findings the traditional string inverter taken for the simulation was the 'Tesla Powerwall 3;' which has a fixed string voltage similar to that of SolarEdge as it function in a way more consistent with a battery inverter. It is worth highlighting that the variable DC to AC conversation of most traditional string inverters with the fluctuating MPPT output would have generated greater conversion losses than this simulation generated.

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Methodology

To verify this modelling and prove its accuracy, SolarEdge took telemetry data from sites installed across Australia between 2018-2023.

State	Systems
Australian Capital Territory	8
New South Wales	89
Northern Territory	2
Queensland	45
South Australia	56
Tasmania	10
Victoria	150
Western Australia	149

SolarEdge DC optimised systems have often been selected by installers due to higher levels of permanent or intermittent shade on a site, or, due to complex roof layouts. Traditionally the yield of a SolarEdge system would be expected to be less than that of a traditional string system installed in a more optimal tilt and orientation in a more favourable location for these reasons.

We obtained data, including the multi-MPPT reanalysis, from 474 residential sites. The analysis was performed over 510 random sites, due to some locations having insufficient data/missing panel model information or other such issues we filtered the sites accordingly. Some sites also comprised of arrays in multiple orientations.

To create a uniform scenario and output values from these sites, we applied a restringing analysis. For this, we first had to estimate the number of facets (tilt and orientation) in the site, and then group together panels of the same facet into strings (as long as they met the minimal voltage requirements being 60V for residential optimisers).

After the restringing arrangement was applied, each string was assigned a 'perfect MPPT'. Then, on the DC side we simulated the production value that was put through our inverter/loss simulation (which is based on, and validated against, PVsyst) to obtain the AC power, which is then compared to our own inverter power telemetries. The AC power generated then allows for any ohmic losses and systems losses as would be expected on a real-life situation as factored into the PVsyst modelling.

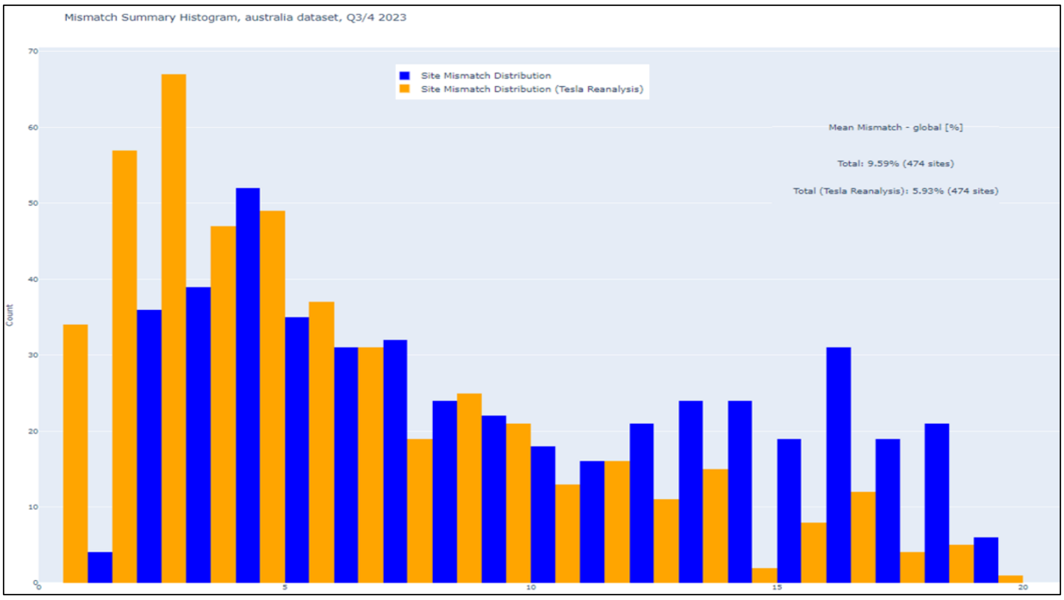
At no point do we make comparisons to "an average across the PV modules", instead we applied the total aggregated sum of all modules when applying the modelling to the string inverter topology.

Results

The analysis returned that SolarEdge systems generated 5.95% more yield from actual installations throughout Australia (from the randomly selected sites) when we compared the PV module IV curve modelling of the traditional multi MPPT input from string inverter system using the modelling values, losses and efficiencies taken from PVsyst. When compared to a single MPPT of a traditional string inverter the additional yield value was >9%

There was a negative bias against the SolarEdge systems in this modelling as the SolarEdge systems are commonly selected by installers to be installed on sites with higher levels of permanent or intermittent shade, or due to complex roof layouts than that of traditional string systems.

It should also be noted that the modelling assumed that each module within the traditional string system had the ability to be able to produce all power at the maximum MPPT for the given IV curve which would not be the case in practice.



To generate more comparable findings the traditional string inverter taken for the simulation was the 'Tesla Powerwall 3[1]' of which the MPPT operates under a fixed string voltage similar to that of SolarEdge as it functions in a way more consistent with a battery inverter. It is worth highlighting that the variable DC to AC conversation of most traditional string inverters with the fluctuating MPPT output would have generated greater conversion losses than this simulation generated.

1 - https://service.tesla.com/docs/Public/Energy/Powerwall/Powerwall-3-with-Gateway-3-Installation-Manual-NA-EN/GUID-EC527BC7-4750-4425-BBC4-DB8C000339B3.html