WHITE PAPER

SolarEdge TerraMax™ Inverter:

The Economic Benefits of DC Optimization in Ground-Mount Solar

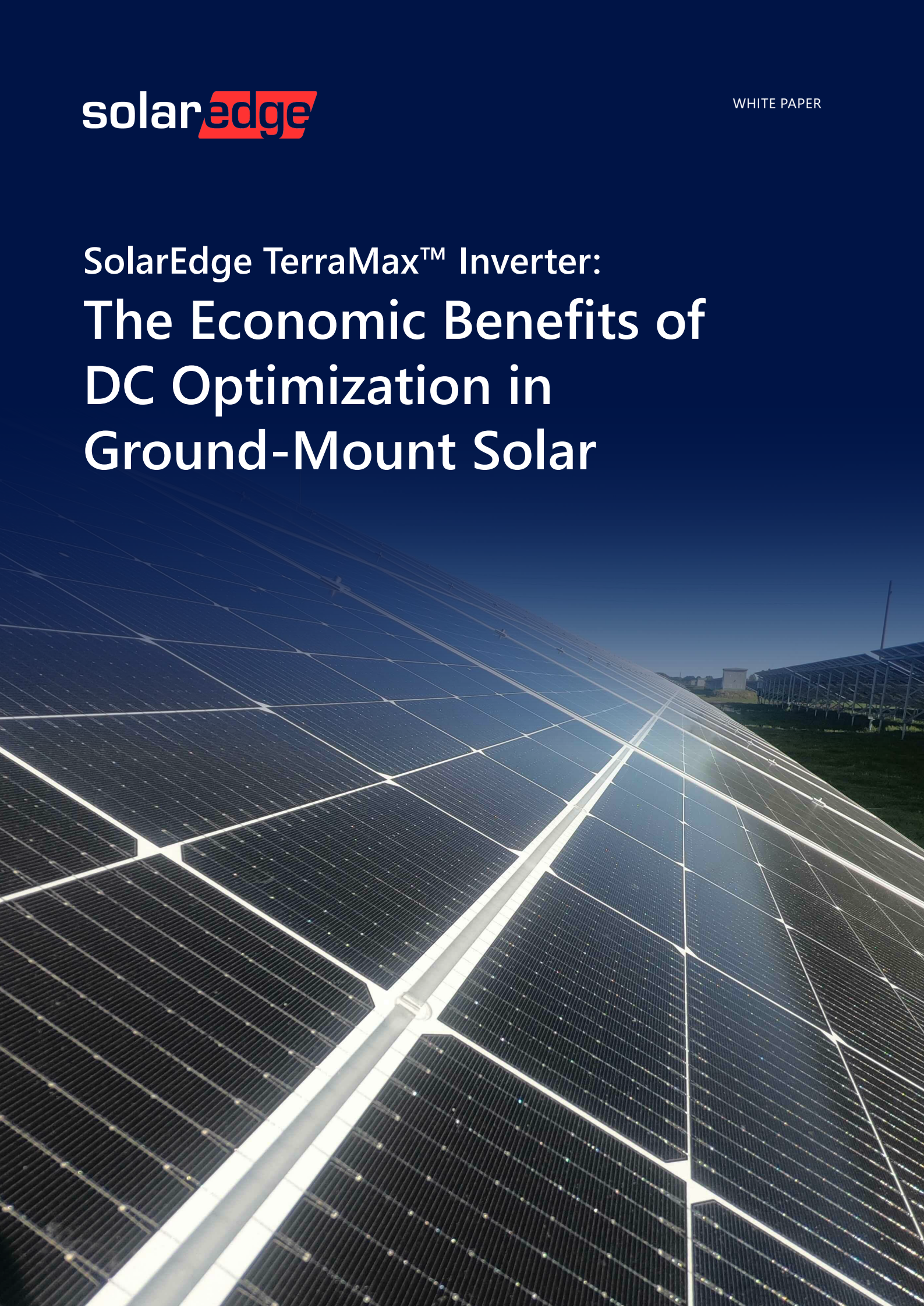
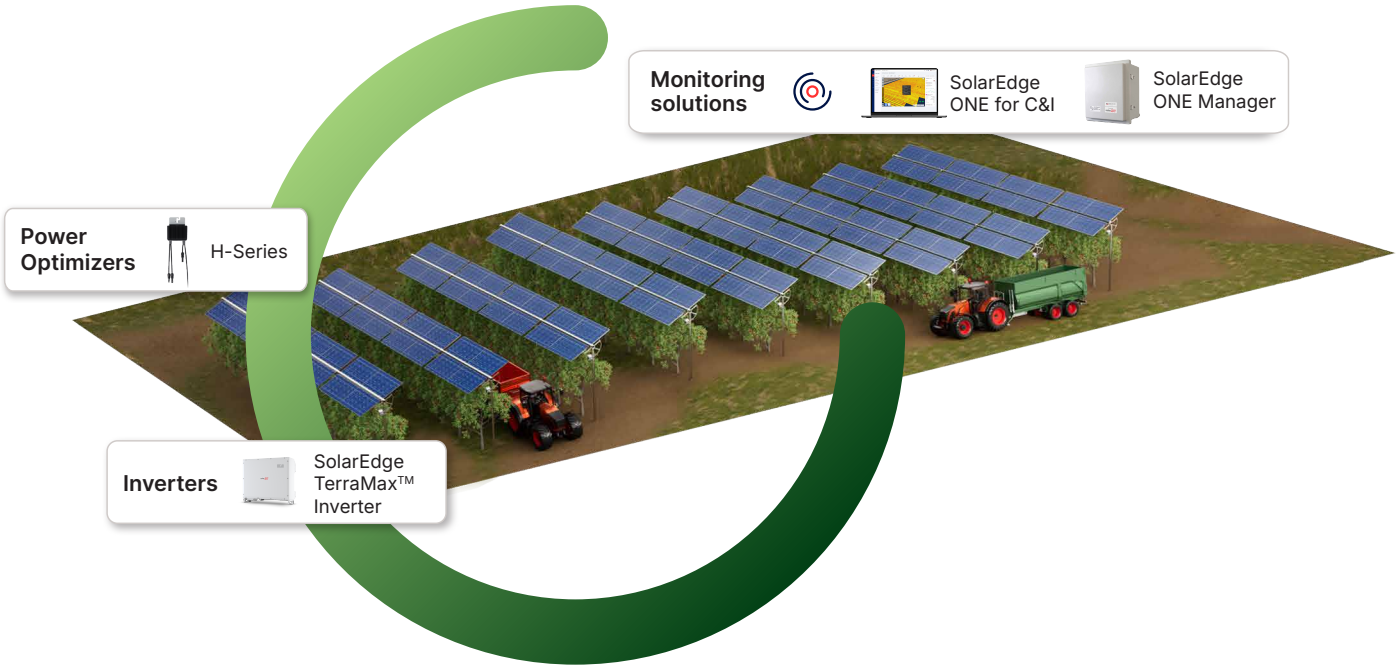


Table of Contents

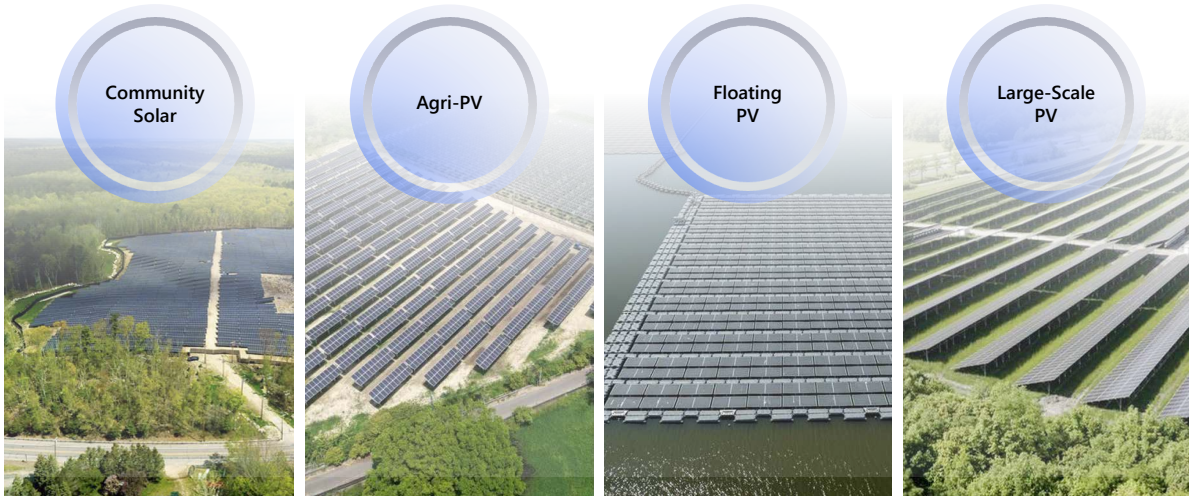
Solution Overview

SolarEdge solutions are implemented on 350k+ sites, including over 50% of Fortune 100 companies that have SolarEdge technology on their rooftops. Our large-scale installations span verticals from Community Solar and Ground-mount and dual-use such as Agri-PV and floating PV.

The SolarEdge Solution for Large-Scale Ground-Mount Projects



Designed for Your Application



Executive Summary

Our next-generation solution for large-scale ground mount projects is designed to overcome non-standard terrain – which may be rocky or uneven – and meet unique site requirements with resilient and versatile technology. The SolarEdge TerraMax™ Inverter delivers up to 330kW of power with high efficiency and module-level visibility, setting new standards for energy yields, while lowering O&M costs:

More Energy

- Up to 6% more energy* revenue than traditional string inverter solutions*
- Granular MPPT with DC optimization

Reduced BoS Costs

- Up to 50% Balance of System (BoS) savings
- Less cabling, fuses and labor cost with longer and fewer strings – up to 80 modules per string
- Full tracker table utilization with string length flexibility

Unique Architecture

- Single DC Input optimized for Virtual Central topology
- Module-level Maximum Power Point Tracking (MPPT) for maximum energy harvest

Lower O&M Costs

- DC Optimization enables real-time monitoring of the DC array with continuous and granular monitoring, providing full visibility into system issues including tracker, DC combiner, and modules
- Reduced need for fly-over inspections

Optimized Safety and Cybersecurity

- Complies with global safety and cybersecurity standards
- SafeDC™ feature eliminates high voltage hazards and maintains touch-safe levels during PV array faults or maintenance

* Validated by PV AMPS, an Independent Engineering Firm

Limitations of Other String Inverter Topologies

Previously, in the string inverter category, we have seen two leading topologies:

- One with multiple maximum power point tracking (MPPT) inputs which provides 12 to 16 MPPT per inverter [see Figure 1]. This is the typical topology of a multi input string inverter. Each MPPT can accommodate up to 2 strings for a total of 24 or 32 strings.
- One with a single DC input allowing for a combined DC bus but with only one MPPT per inverter [see Figure 2].

In this traditional architecture, in the multi-MPPT string inverters [Figure 1], the inverters are distributed throughout the array. While this reduces DC BoS costs, it increases AC BoS costs and AC losses due to the long AC wiring runs. Additionally, as the DC:AC ratio increases, this configuration will experience greater disadvantages as it cannot take advantage of the free voltage drop that is possible during times of clipping. Another drawback is the higher cost of communication circuits to inverters spread across the array. The advantage of this configuration is that it allows for increased energy harvest due to the number of MPPT per inverter.

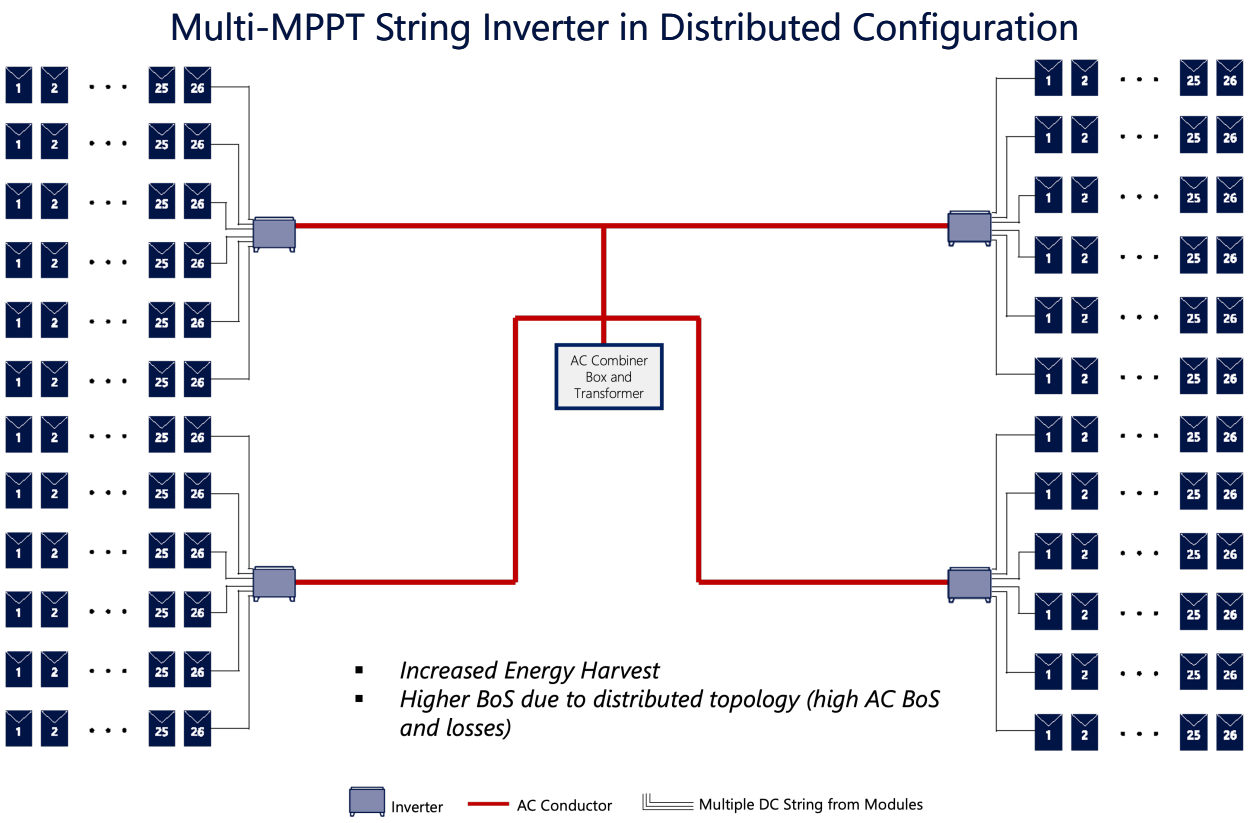


Figure 1 – Multi-MPPT Inverter String Inverter

The other solution in the market has inverters with single DC input [Figure 2]. In this case, the string inverter has a single DC input which allows the use of DC combiner boxes or wire harnesses with aluminum feeders to reduce DC cabling costs. However, since these inverters only have one MPPT, the energy harvest is lower when compared to the multi-MPPT inverter solution. So, while electrical balance of system costs can be reduced, energy production is also lowered.

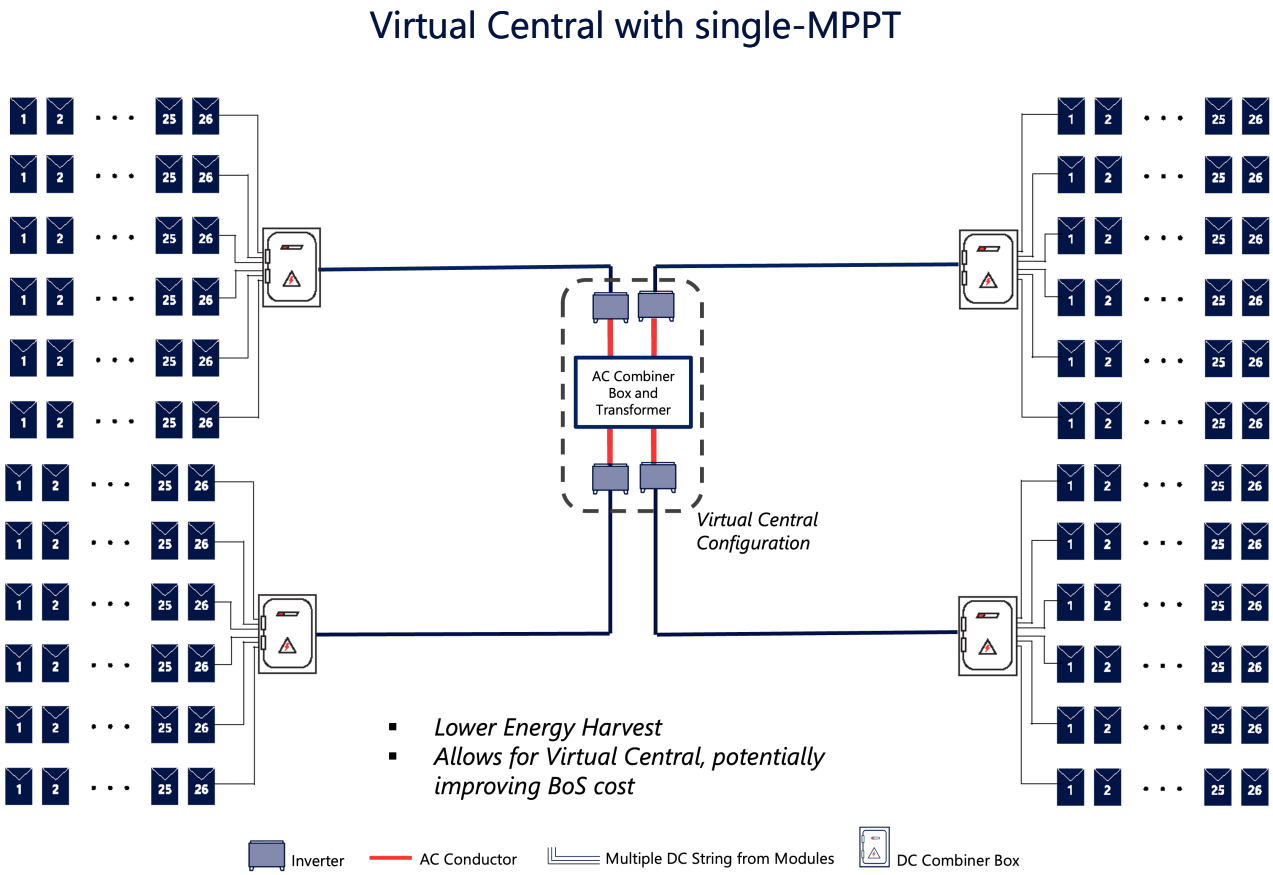


Figure 2 – Single DC Input String Inverter

The Best of Both Worlds: The TerraMax DC-Optimized Solution

Each of the previous solutions has its pros and cons – you can either optimize BoS or energy production, but not both. However, the new TerraMax DC-optimized solution [Figure 3] allows installers and owners to enjoy the best of both worlds – optimized BoS and superior energy harvest. Superior energy production is achieved with DC optimization which performs module-level MPPT.

It combines the benefits of virtual central inverter configuration, which are low AC costs and AC losses, and easier O&M with the benefits of string inverters (modularity and plant availability). At the same time, DC cabling costs are kept low by using DC combiner boxes or trunk bus solutions and aluminum feeders.

DC optimization allows for even longer strings when compared to conventional 1500VDC string inverters, as well as the flexibility to use strings of different lengths. This solution enables up to 80 modules connected per string. Longer strings of modules translate into fewer strings per inverter, which means fewer disconnects and fuses – and overall savings on DC cabling.

Unique Architecture: Virtual Central with DC Optimized SolarEdge Solution

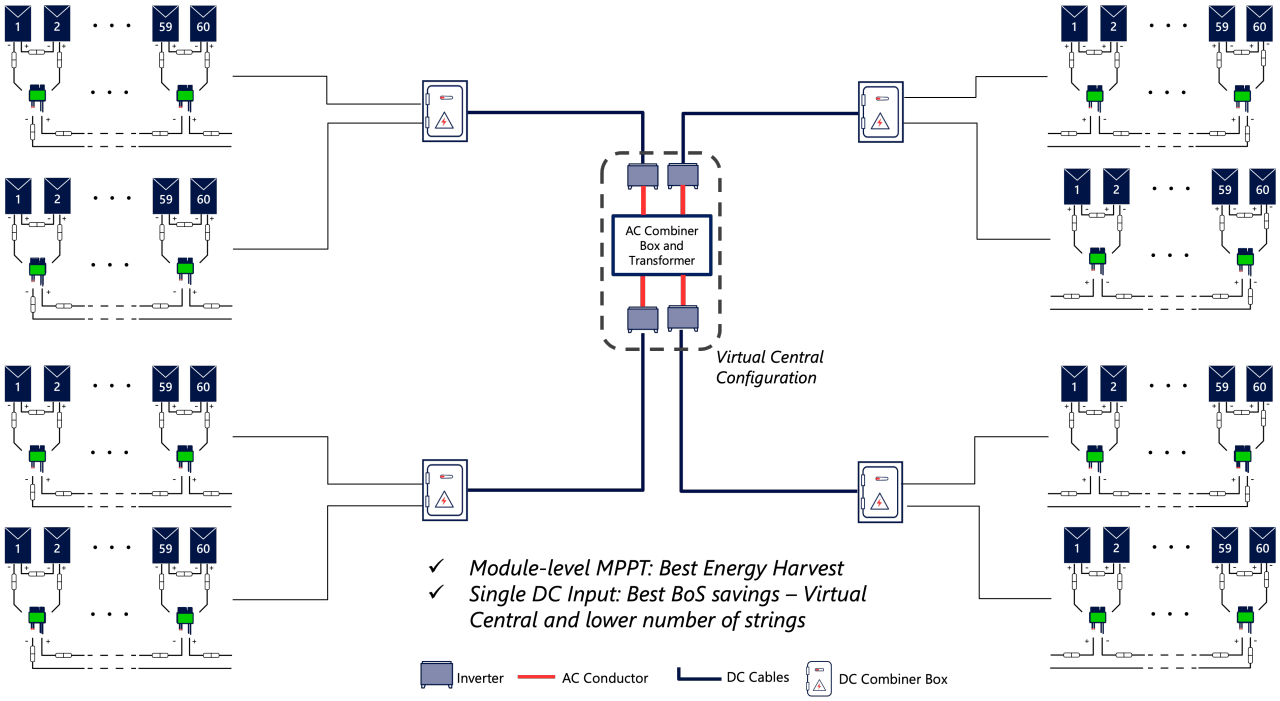


Figure 3 - TerraMax System - Unique Architecture

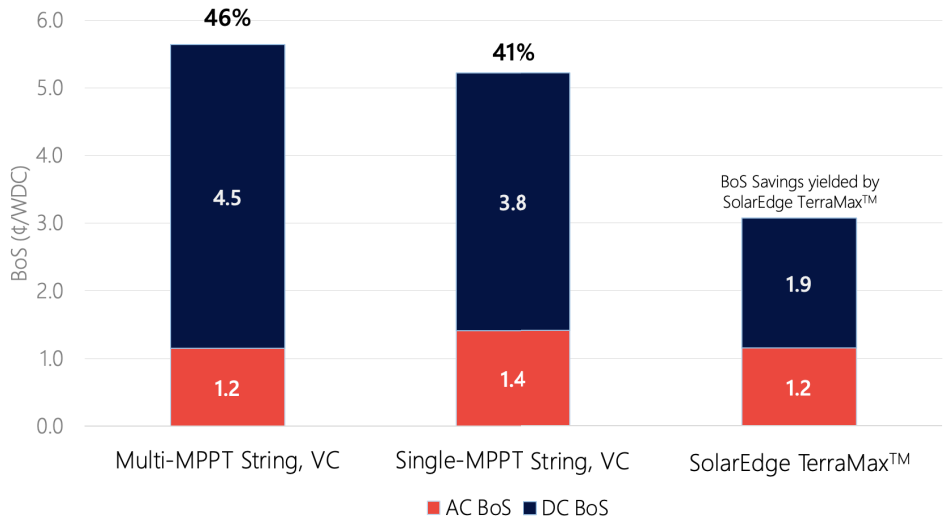
TerraMax Benefits Explained

BoS Savings in a 7.7MWdc Community Solar Project:

To compare the three configurations for balance of systems cost and energy production, we worked with PV AMPS, an independent engineering firm, to create BoS models using the topology of a community solar project in the Northeastern U.S. This project was chosen because it's typical of many community solar projects with irregular shaped fields and sloped terrains. The BoS savings are greater than 42% when comparing the two string inverter solutions and the TerraMax.

The TerraMax DC-optimized solution provides the lower electrical BoS costs for both AC and DC circuits. This advantage comes from using DC Optimization, which lowers the number of strings and reduces DC BoS. The Virtual Central configuration places the inverter in a central location, cutting down AC BoS. Additionally, the larger 330kW inverter size means fewer inverters are needed for each plant.

Up to 50% Balance of System Savings



*The BoS comparison methods and results have been independently reviewed and validated by PV AMPS, an independent engineering firm. Cost of parts for inverters and optimizers are not included in the BoS comparison. Analysis for a 7.7MW project with a typical design. Numbers vary based on project sizes, components and location.

Energy Harvesting Superiority: Mitigating Module Degradation

An energy calculation for the three models, using the same site was performed in PVSyst, which was validated by PV AMPS. The TerraMax DC-optimized system provided significantly better energy production and revenue when compared to both string inverter solutions. The Net Present Value (NPV) energy revenue gains over 20 years are designed to be greater than $1M when compared to traditional string inverters.

This is because energy is harvested at the module level, therefore overcoming module mismatch, and ensuring that all modules always work at their maximum power point regardless of the performance of other modules in the PV string.

Up to 6% More Energy* Revenue Compared to Older String Inverters

	Conventional String Inverters		SolarEdge	
YoY Energy Production	Multi-MPPT String	Single-MPPT String	TerraMax™ Inverter	Our Advantage (NPV Energy Gains over 20 years)
Year 1	10.04 MWh/y	9.97MWh/y	10.45 MWh/y	Vs. Multi-MPPT: up to $1M (~5%) Vs. Single-MPPT: Up to $1.1M (~6%)
Year 20	9.08 MWh/y	9.01MWh/y	9.78 MWh/y	
NPV Revenue – 20 years	$16.7M	$16.6M	$17.7M	

* Source: PVSyst analysis for this specific project. The Energy comparison methods and results have been independently reviewed and validated by PV AMPS, an independent engineering firm. Analysis for a typical 7.7MW project. Numbers vary based on project size, components and location. Calculation using 12c/kWh, discount rate of 6%.

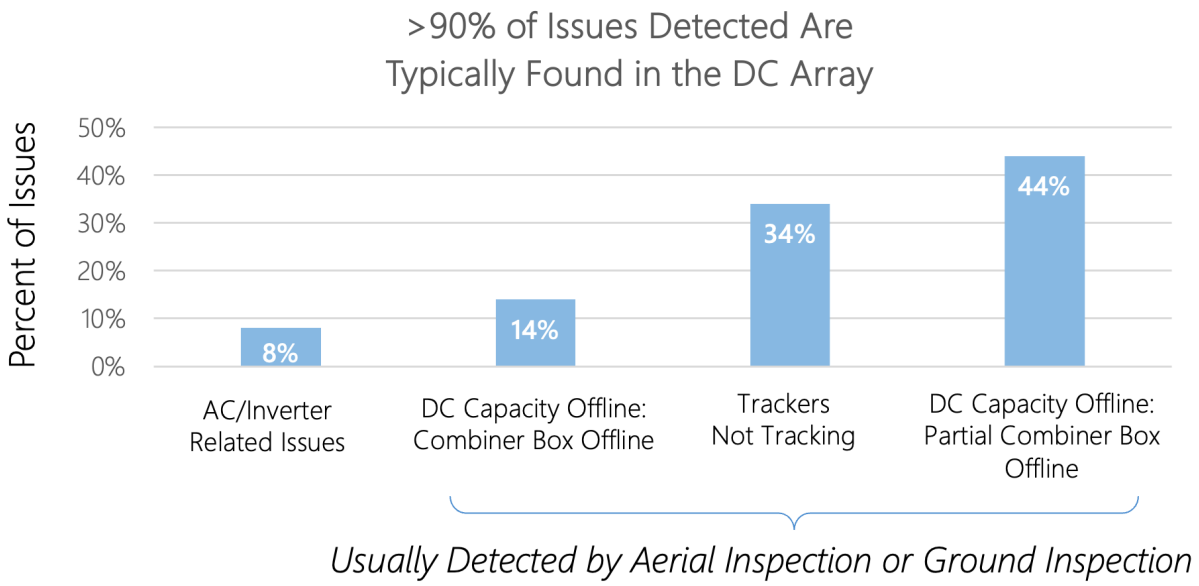
O&M with DC Optimization – Real-Time Visibility into Plant Issues

A key advantage of DC optimization is that monitoring is continuous at the module level, so voltage, current, and energy production levels are provided for each power optimizer (each optimizer is connected to two modules).

With SolarEdge ONE, energy optimization platform, this solution is designed for full visibility of plant issues, including the DC side of the plant. According to data from NovaSource, more than 90% of plant issues happen on the DC side of the plant. With string inverters, these are typically only detected via aerial inspection, which happens once or twice a year. Module-level monitoring enables continuous and granular data of issues so they can be caught early. It also provides the asset manager with reports and data to determine if a crew needs to be dispatched.

Over the life of the project with full visibility on plant issues, we estimate savings of $50k per MWdc on O&M expenses. These savings come from a reduced need for aerial inspections and fewer truck rolls. Moreover, during any O&M activity in the array, string conductors are de-energized to touch-safe voltage levels, improving personnel safety.

100% Visibility into Plant Issues



With SolarEdge, savings of ~$50k/MWdc (NPV) over project life on O&M Expenses

- Continuous and granular data enables complete visibility into DC array
- Aerial imagery is the only way to identify DC array issues without DC Optimization
- Increased visibility = Increased system uptime

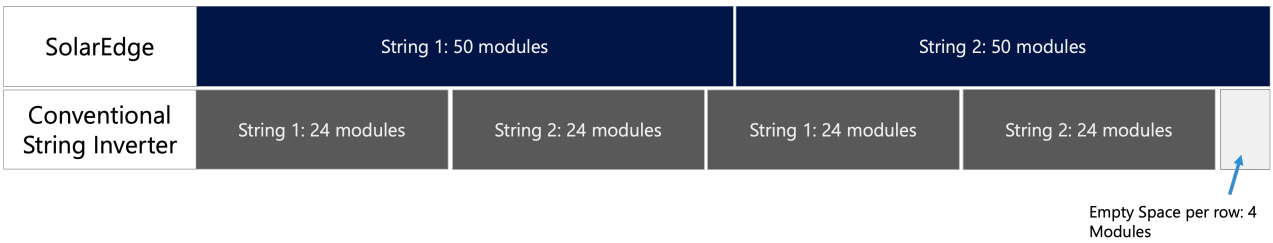
Source: NovaSource, industry leading independent O&M and performance reporting/data quality verification firm for renewable energy assets.

Optimizing Tracker Usage

Tracker manufacturers design their tracker tables to accommodate a certain number of modules per table. Tracker tables can fit between 96 to 120 modules per tracker table.

For a given tracker designed for 100 modules, the TerraMax system enables the tracker table to be fully populated with two strings of 50 panels each due to DC Optimization, as it allows for longer strings and flexibility in string lengths (anywhere between 44 and 80 modules).

On the other hand, when using a conventional string inverter that only allows for a fixed number of panels per string (typically 24-28 modules), one table can only fit 4 strings of 24 panels each (for instance), resulting in 96 modules per tracker table. This means that the tracker table is not fully used – leaving about 4 module positions empty.



In this example, by fully using the tracker table, the designer can place 4 more modules per tracker table. The net effect is that 500 more modules are installed in the plant for the TerraMax system totaling 305kWdc more DC power using the same number of tracker tables and ground coverage ratio (GCR).

Parameters	SolarEdge	Conventional String Inverter
System kWdc	**7625**	**7320**
GCR	33.5%	33.5%
Tracker Tables	125	125
Energy Production Year 1	+6.02%	
Energy Production Year 20	+8.99%	

$1.4M in energy revenue gain over 20 years ($600k due to extra modules per TerraMax tracker table optimization)

Increased energy revenue of up to $1.4M can come from the SolarEdge system's module level MPPT, which is designed to harvest more energy. $600k of this total is due to the additional 305kWdc from the 500 extra panels added by fully using the tracker tables.

Enhanced Safety and Cyber Security

An Industry Leader in PV Safety

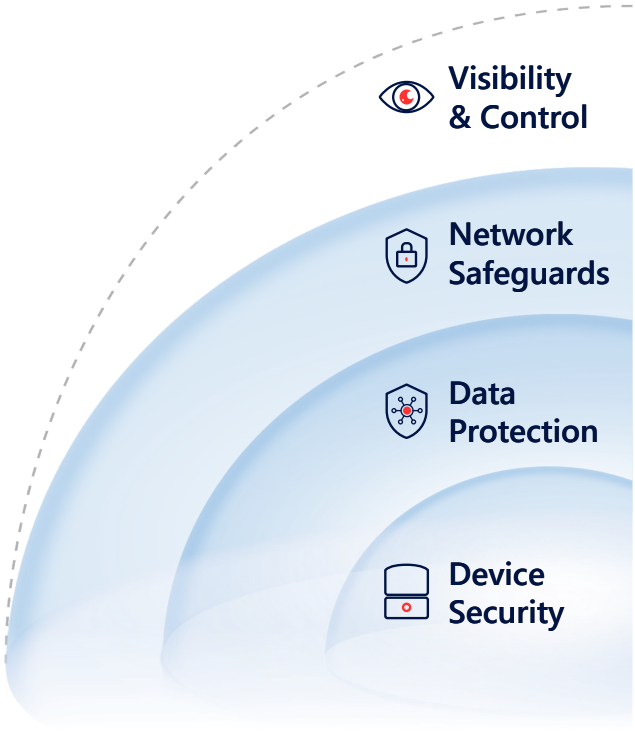
The SolarEdge solution is synonymous with safety, complying with the most stringent international safety standards, even surpassing some existing industry requirements.

SolarEdge's holistic approach to PV safety is built on three main foundations: prevention, detection and mitigation.

The SolarEdge TerraMax Inverter has the built-in SafeDC feature, designed to lower DC voltage to touch safe levels and provide a safer work environment for maintenance and emergency crews.

Setting the Standard for Solar

Just like solar safety, solar cybersecurity is non-negotiable. By partnering with SolarEdge you get extra protection, throughout the entire PV system lifetime. Our tiered approach to cybersecurity is aimed at protecting data integrity, communications, and business operations from site commissioning through to production. We continuously adapt and enhance our solutions to align with evolving demands and regulatory standards.



We prioritize the needs of our customers' security teams by designing our products not just to be secure but to also ensure maximum visibility and control for our users.

The PV inverters' local connectivity functions are designed with security in mind, to maximize network protection.

User data and energy usage data is securely transferred and stored, ensuring maximum data privacy and protection from cyberthreats.

SolarEdge inverters are the heart of the PV system, and together with other SolarEdge devices, are designed to prevent and detect PV system-wide cyberattacks.

Conclusion:

Why Use Power Optimizers for Ground-Mount

As shown throughout this document, there are clear benefits when using DC Optimization in Ground-Mount applications. The benefits to energy production, and savings on BoS and O&M are clear. For organizations and developers looking to own a solar project for its entire life, the benefits in energy production can increase revenue and asset value. A common concern is whether the addition of DC-optimized module-level power equipment in Ground-Mount projects will affect overall system reliability. The following items address this concern:

- Based on the SolarEdge installed fleet, Power Optimizers failure rates for the latest generations of optimizers is below 0.3% (fleet reliability)
- SolarEdge provides the AdvantEdge program, which is a performance guarantee for issues with optimizers, i.e., any loss of production for optimizers in the first 2 years will be covered by this program, plus optimizers have a 25-year warranty
- If one optimizer has an issue, only two solar modules will stop producing, and it can be replaced at the next service visit to the site, which the AdvantEdge program helps to offset its cost
- SafeDC feature reduces string voltage to touch-safe levels upon a fault and during commissioning and maintenance.