SOLAREDGE – TERRAMAX™ INVERTER AND POWER OPTIMIZES SOLUTION

Technology Review Report

SolarEdge Technologies Ltd.

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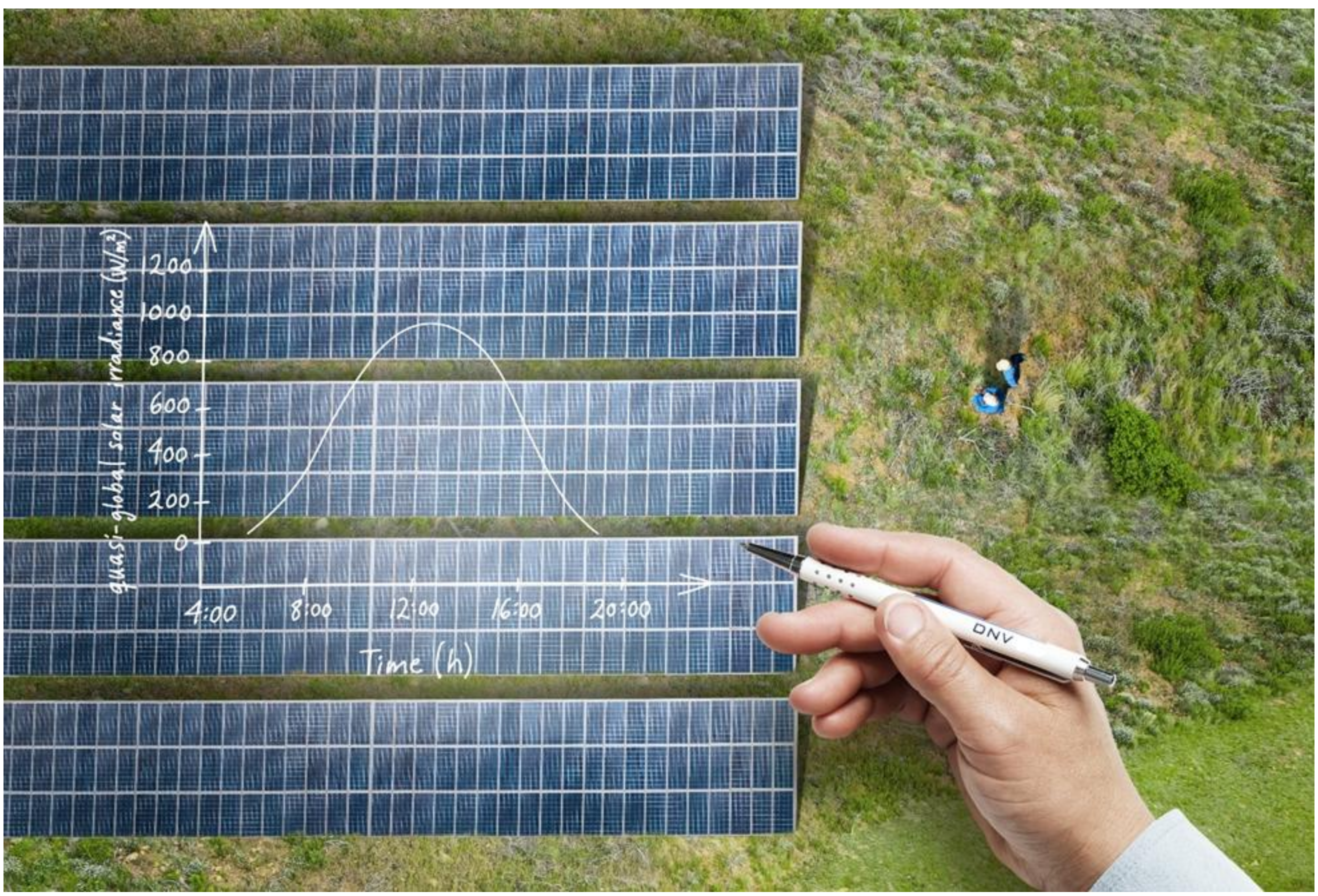

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Task and objective:
This report presents the results of analysis conducted by DNV on behalf of SolarEdge Technologies Ltd.

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List of abbreviations

Abbreviation	Meaning
AC	alternating current
AFCI	arc fault circuit interrupter
ALT	Accelerated life test
ATP	acceptance test procedure
BESS	Battery energy storage system
BMS	Battery management system
CAN	controller area network
CEC	California Energy Commission
DNV	DNV Energy USA Inc.
DVT	design verification test
DC	direct current
EHS	Environmental, Health, and Safety
EMI	electro-magnetic interference
EOL	end of line or end of life
ERP	Enterprise Resource Planning
ESD	electrostatic discharge
ESG	Environmental, social, and governance
ESS	Energy storage systems
EV	Electric vehicle
FMEA	failure modes and effects analysis
HALT	highly accelerated life testing
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
IGBT	Insulated gate bipolar transistor
MPPT	Maximum power point tracking
MTTR	Mean time to repair
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NPC	Neutral point clamped
NRTL	Nationally Recognized Testing Laboratory
O&M	operation and maintenance
PV	photovoltaic
PID	potential induced degradation
PCB	printed circuit board
PCS	Power conversion system
QMS	quality management systems
RSS	rapid shutdown system
RMA	return material authorization
SLD	Single line diagram
SPD	Surge protection devices
STATCOM	Static synchronous compensator
TDD	Total demand distortion

Abbreviation	Meaning
THD	Total Harmonic Distortion
UL	Underwriters' Laboratories

1 INTRODUCTION

SolarEdge Technologies Ltd. ("SolarEdge") retained DNV Energy USA Inc. ("DNV") to perform an independent technology evaluation of SolarEdge's new inverter for utility-scale Photovoltaic (PV) applications. This report presents the results of DNV's analysis.

1.1 Executive summary

Throughout this report, comments are made that should be reviewed in detail indicating the views of DNV on key areas of product design and performance. The comments herein resulted after reviewing extensive documentation presented by SolarEdge, interviewing key personnel, and performing a manufacturing review at the partner manufacturer facility.

Table 1-1 provides a summary of DNV's review findings.

Table 1-1 Evaluation Summary

DNV key findings	
Company evaluation	• Ranked #1 manufacturer in the US residential inverter market with a 56% share. Leader in the PV optimizer field. • Ranked #4 and #7 manufacturer in Europe and the US, respectively, in terms of total PV inverter market share (% of shipped MWac)
	• Long track record in developing residential and commercial PV solar inverters and optimizers.
	• Five manufacturing plants around the world for optimizers and inverters including their own production facility in Israel. SolarEdge and contract manufactures are certified to ISO 9001:2015 and ISO 14001:2015.
	• Expansion of product offerings with continual investment in R&D.
	• This report constitutes the sixth review by DNV of SolarEdge and its products.
Product evaluation	• The TerraMax series of PV inverter and associated optimizer products for utility-scale and large commercial photovoltaic installations, with extensive compliance testing and regulatory certifications to allow for installation in global PV markets.
	• Thorough approach to product reliability following the best industry practices that includes design for reliability, reliability testing, and objective analysis of field failure data for product reliability improvements.
	• Detailed design process, repeatable manufacturing processes and effective quality systems are in place.
	• Optimizers enable module level MPPT, monitoring, and diagnostics options to improve overall PV plant performance.

	• Optimizers and inverters are equipped with safety systems to detect over-temperatures caused by improper connections and damage.
	• Power conversion efficiency is high for similar converters in the marketplace.
	• Effective service approach in supporting PV systems installations with software, product manuals and white papers. Equipped with communications systems for PV module level monitoring and remote troubleshooting.
	• A limited field history of TerraMax series inverters is available. Expected failure rate discussed in Section 4.5 provides insight into future O&M costs. System integrators should review this discussion. • The optimizers reviewed in this report do not have field history data. However, SolarEdge significant experience and has thorough reliability practices for new product development.
	• SolarEdge offers a standard warranty of 25 years for the optimizers under review and a standard warranty of 5 years for the TerraMax PV inverters. • The reliability track record of the industry highlights the necessity of a strong warranty and a supportive manufacturer. In DNV's opinion, warranty duration and terms for optimizer and inverter are in line with PV industry standards.

Based on the documentation reviewed and the site visit conducted, DNV does not identify any fundamental barriers to the successful deployment and operation of SolarEdge's TerraMax series PV inverters and associated power optimizers in the intended applications. This report details various DNV findings related to the product.

1.2 Scope of review

This review presents DNV's independent technology review of SolarEdge's H-series power optimizers- H1300 and H1500 as well as TerraMax series PV inverters – SE330KUS, SE250KUS, SE285KUS, SE300K, and SE330K. The TerraMax series is intended for use in ground-mounted community solar, agricultural, and floating PV systems.

1.3 Methodology

In general, this report contains information that would be included in a final Independent Engineering review intended for financial institutions, customers, and project developers. DNV is uniquely qualified to conduct this study due to its extensive background and experience in solar independent engineering and technology due diligence work.

For this report, information was aggregated from multiple SolarEdge sources and provided to DNV by:

- Guy Shaked – Product Manager, Utility
- Eran Haskel - Director of Product Operations
- Tal Eliya - Project Manager R&D
- Yoav Berger - Commercial Inverter Director, R&D
- Nadav Berkovich - Senior Director of Embedded Control, R&D

- Elad Moskovich - Optimizers Director, R&D
- Aharon Rochman - VP of Global Quality, Q&R
- David Lachmann - AVP of Reliability, Q&R
- Yaniv Shitrit - AVP of Component Reliability, Q&R
- Aviad Yeshaya - Senior Director of Compliance Certification

The primary objective of this report is to assess factors that would affect the product's performance and reliability in the field and the company's ability to deliver and service the products. Such factors will include the design, quality of materials, product performance, regulatory compliance, reliability tests, and the manufacturing and quality control processes.

1.4 Assumptions

This Report summarizes DNV's assessment of the technology and relies on the accuracy of the information provided by SolarEdge. SolarEdge has been open and forthcoming in providing the data that DNV has requested. Some data received from SolarEdge has been excluded from inclusion in this report based on requirements from SolarEdge that it remains confidential.

This report is based on some information not within the control of DNV. DNV believes that the information provided by others is true and correct and reasonable for the purposes of this report. DNV has not been requested to make an independent analysis or verification of the validity of such information. DNV does not guarantee the accuracy of the data, information, or opinions provided by others.

In preparing this report and the opinions presented herein, DNV has made certain assumptions with respect to conditions that may exist, or events that may occur in the future. DNV believes that these assumptions are reasonable for purposes of this report, but actual events or conditions may cause results to differ materially from forward-looking statements. Issues that would benefit from further clarification or require additional information to resolve are highlighted using ***bold italics.***

2 COMPANY EVALUATION

2.1 Company overview

SolarEdge was founded in August of 2006 and is headquartered in Herzlia Israel, near Tel Aviv. The SolarEdge headquarters building is shown in Figure 2-1 below. The North American headquarters is in Milpitas, California. SolarEdge has the international subsidiaries and sales/support offices as shown Table 2-1. SolarEdge maintains a global presence through subsidiaries and offices in over 25 countries. As of Q3 2024, SolarEdge reports having shipped approximately 55.3 GW of DC-optimized inverter systems globally, serving more than 4.1 million monitored systems across 140+ countries. The company has over 4,000 employees worldwide.

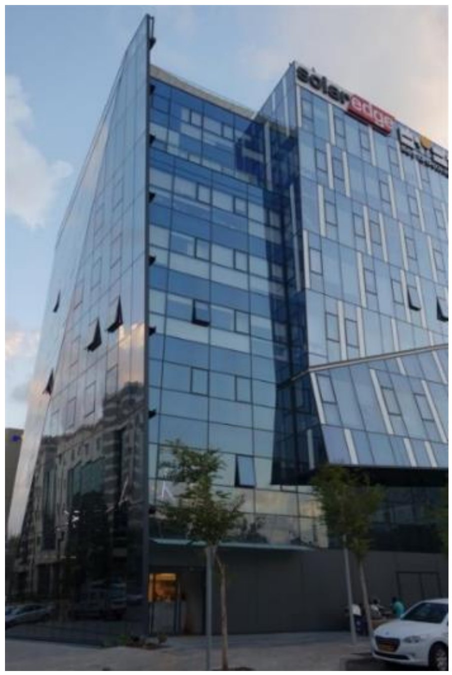

Figure 2-1 SolarEdge Headquarters in Israel

Table 2-1 SolarEdge Technologies subsidiaries around the world

Name	Location
SolarEdge Technologies Ltd.	Israel
SolarEdge Manufacturing Ltd.	Israel
SolarEdge Technologies GmbH	Germany
SOLAREDGE TECHNOLOGIES (CHINA) CO., LTD	China
SolarEdge Technologies (Australia) PTY LTD	Australia
SolarEdge Technologies (Canada) Ltd.	Canada
SolarEdge Technologies (Holland) B.V.	The Netherlands
SolarEdge Technologies (Japan) Co., Ltd.	Japan
SolarEdge Technologies (France) SARL.	France
SolarEdge Technologies (UK) Ltd.	United Kingdom

Name	Location
SOLAREDGE TECHNOLOGIES ITALY S.R.L.	Italy
SolarEdge Automation Machines s.p.a.	Italy
SolarEdge e-Mobility s.p.a	Italy
SolarEdge Investment srl	Italy
SolarEdge Technologies (Bulgaria) Ltd.	Bulgaria
Guangzhou SolarEdge Machinery Technical Consulting Co., Ltd	China
SOLAREDGE TEKNOLOJİ A.Ş.	Turkey
SolarEdge Technologies (Belgium) SPRL	Belgium
SolarEdge Technologies SRL.	Romania
SOLAREDGE TECHNOLOGIES (INDIA) PRIVATE LIMITED	India
SolarEdge Technologies (Sweden) AB	Sweden
SolarEdge Technologies Taiwan Co., Ltd.	Taiwan
SolarEdge Technologies Korea Co., Ltd.	South Korea
Kokam Limited Company	South Korea
SolarEdge Critical Power U.K. Limited	United Kingdom
SOLAREDGE DO BRASIL SERVIÇOS DEMARKETING E APOIO AO CLIENTE LTDA.	Brazil
SolarEdge Technologies (Vietnam) Company Limited	Vietnam
SolarEdge Technologies (Hungary) Kft.	Hungary
SolarEdge Technologies (Poland) Sp. Z o.o	Poland
SolarEdge E-Mobility Germany GmbH & Co. KG	Germany
SolarGik, Ltd.	Israel
SolarEdge Technologies Mexico S.DE R.L. DE C.V.	Mexico

SolarEdge owns and operates five manufacturing plants globally. SolarEdge has five manufacturing plants around the world for optimizers and inverters including their own production facility in Israel. SolarEdge's Sella 1 manufacturing plant started production in Q1 2021. SolarEdge has manufacturing contract agreements with two – Tier 1 electronic contract manufacturers. These manufacturers are Flextronics Inc. (Flextronics) in Hungary and Mexico and Jabil Circuit Inc. (Jabil) in China and Vietnam. DNV visited the Flextronics facility in Hungary as part of an earlier review, as a representative production site. DNV has previously visited other Jabil electronics manufacturing facilities. DNV recognizes Flextronics and Jabil as leading electronics contract manufacturers. DNV did a virtual visit of SolarEdge's new Sella 1 manufacturing location as a part of this review. The findings of the review are presented in Section 5. SolarEdge has set up manufacturing facilities in the US located in Austin, Texas and Seminole, Florida.

The world-wide geographic distribution of SolarEdge operations as provided to DNV is shown in Figure 2-2 below.

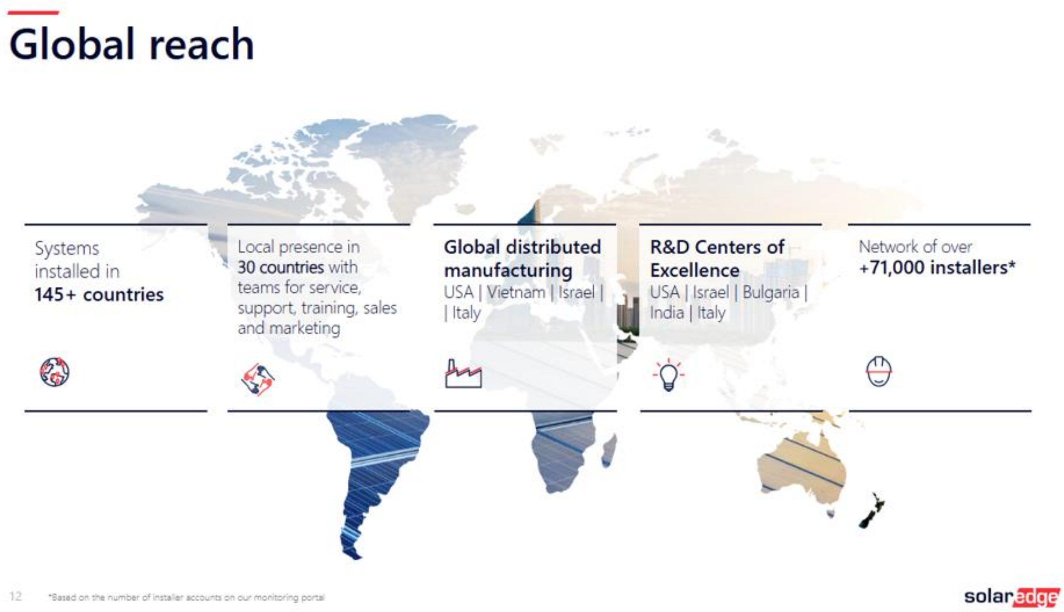

Figure 2-2 SolarEdge global operations

2.2 Company Product History and Technology Roadmap

Figure 2-3 shows SolarEdge's significant milestones achieved since 2006. SolarEdge provided the following significant milestones achieved since DNV's previous review in 2019.

2020: SolarEdge Enhances Solar-Plus-Storage Experience with Launch of Home Hub (aka Energy Hub) Inverter.

2021: SolarEdge Home Battery residential 9.7 kWh, DC coupled battery, launched in North America.

2022: Announced the launch of SolarEdge Home Product Portfolio, an innovative home energy management solution that allows homeowners to optimize their solar energy production, usage and storage. Designed for both single and three-phase applications

2022: SolarEdge Opens 2GWh New Battery Cell Facility in South Korea to Meet Growing Demand for Battery Storage

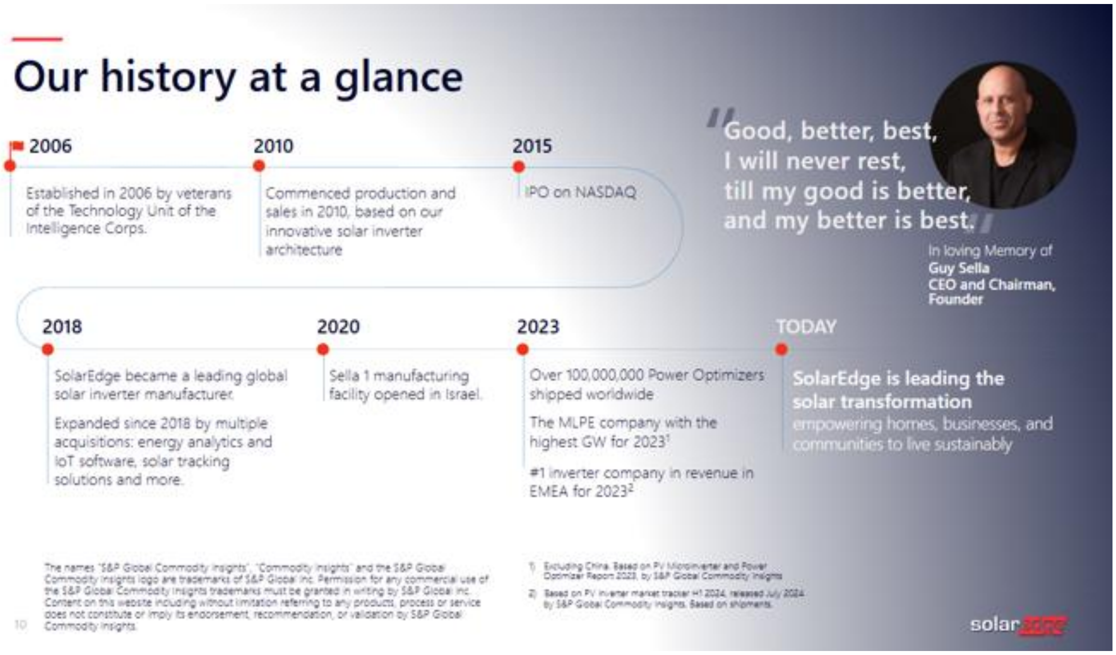

Figure 2-3 SolarEdge milestones

2.3 Installations

The SolarEdge TerraMax inverters have recently been installed for agri-PV and floating PV installations. SolarEdge Terramax PV inverters are used in a 13 MW agri-PV installation in northern Israel, as shown in Figure 2-4 and Figure 2-5. The TerraMax inverters have also been installed in a 17.3 MW floating PV plant shown in Figure 2-6.

Figure 2-4 13 MW installation of agri-PV in Northern Israel using SolarEdge TerraMax PV inverters

Figure 2-5 13 MW installation of agri-PV in Northern Israel showing used SolarEdge TerraMax PV inverters

Figure 2-6 17.3 MW floating PV installation in Southern Israel using SolarEdge TerraMax PV inverters

2.4 Sales, Revenue, and Market Performance

SolarEdge is a publicly traded company on the NASDAQ under the symbol "SEDG" and has been reporting financial results since its IPO in 2015. The company has demonstrated substantial revenue growth over the past several years, with a notable peak in 2022 before facing macroeconomic and operational headwinds in 2023 and 2024. The revenue, gross margin, net income, and compound annual growth rate (CAGR) are shown in Table 2-2 and Figure 2-7. Despite pressures in

2023 and 2024, the company retains a significant revenue base supported by a large global installed base and continued shipments across key product categories.

Table 2-2 SolarEdge's year-on-year revenue, gross margin, and net income

Year	Revenue ($M)	Gross Margin (%)	Operating Income ($M)	Net Income ($M)
2021	1,964	32.0	207.1	169.2
2022	3,110	27.2	166.1	93.8
2023	2,977	23.6	40.2	34.3

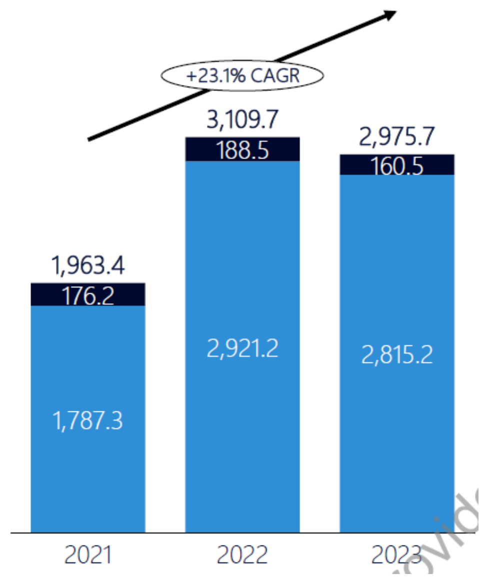

Figure 2-7 SolarEdge's compound annual growth rate

SolarEdge continues to report strong shipment volumes across its product lines. Cumulative shipments in 2023 and through Q3 2024 are presented in Table 2-3. SolarEdge has a global footprint, with recent shipments distributed across different regions is shown in Figure 2-8.

Table 2-3 Cumulative shipment from SolarEdge in 2023 and till Q3 2024

Product Category	Q3 2024	YTD (Q1–Q3 2024)	2023 Total
Power Optimizers (units)	1.85M	5.1M	17.43M
Inverters (units)	57,642	192K	1.01M
MW Shipped (total)	850	2.7GW	12.6GW
Battery Storage (MWh)	189	445MWh	744MWh

	2019	2020	2021	2022	2023
North America	2,260	2,276	2,496	3,396	2,667
Europe	2,513	2,690	3,247	5,478	8,321
ROW	845	1,139	1,417	1,617	1,640
	5,618	6,106	7,159	10,491	12,629

Figure 2-8 SolarEdge's MW shipped by region

Significant additional information can be found on the company website as part of their information filings associated with an exchange-listed company.

2.5 Intellectual property (IP) evaluation

SolarEdge is focused on protecting the IP that it has developed for their optimizer and inverter products. DNV reviewed the overall SolarEdge company IP strategy through a number of discussions. DNV understands that SolarEdge conducts routine reviews of patents in its field in order to protect its patents and to gauge the state of the existing IP in their product areas.

As of Q3 2024, SolarEdge holds:

- 576 granted patents
- 387 pending patent applications

These span across multiple jurisdictions and product lines including inverters (single and three-phase), optimizers, smart modules, EV chargers, storage interfaces, and control systems. The company continues to update its IP portfolio and protect developments across smart energy solutions.

DNV has reviewed SolarEdge's IP strategy in past assessments and noted their partnership with Banner & Witcoff, a U.S.-based IP law firm.

3 TECHNICAL EVALUATION

The technical evaluation describes the features and performance ratings of SolarEdge's TerraMax series PV inverters. The TerraMax series is intended for use in ground-mounted community solar, agricultural, and floating PV systems. It features a virtual central architecture with a single DC input and employs module-level maximum power point tracking (MPPT).

Since DNV's previous review in 2022, SolarEdge's product offering for residential and commercial applications has increased. SolarEdge is also offering higher power rated optimizers and three phase inverters for commercial and utility scale applications.

The SolarEdge system components under review in this report consist of the following primary components:

- Power Optimizers – H1300 and H1500
- TerraMax Series three-phase PV inverters – SE330KUS, SE250KUS, SE285KUS, SE300K, and SE330K

A high-level schematic of a SolarEdge photovoltaic (PV) system is shown in Figure 3-1. In this configuration, two PV modules are connected to a dedicated power optimizer. The outputs of these optimizers are connected in series to form strings, which are then connected to a SolarEdge inverter via a combiner box (see Figure 3-2). This inverter serves as the interface between the PV array and the utility grid.

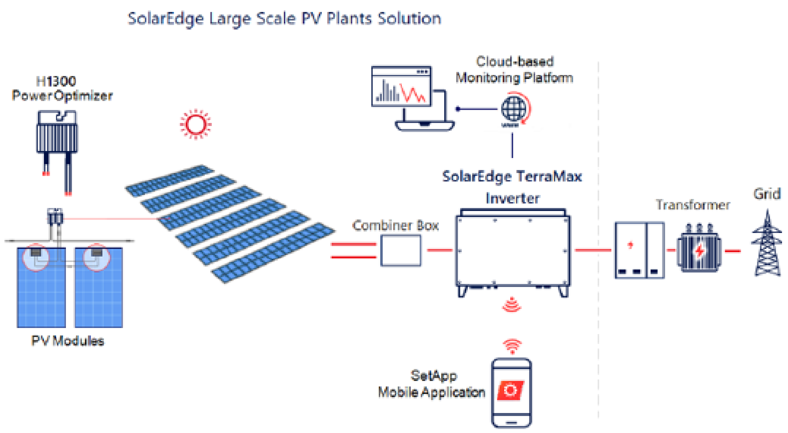

Figure 3-1 SolarEdge PV System Diagram

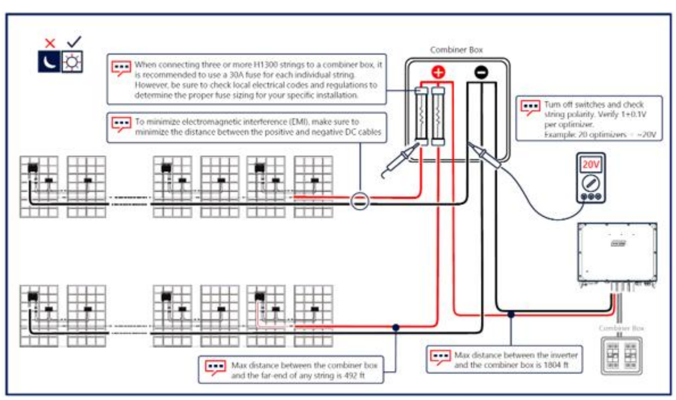

Figure 3-2 Connection of PV modules to Optimizer and the string to combiner box

The complete SolarEdge system architecture consists of three key components:

- PV Module Power Optimizers – These perform module-level maximum power point tracking (MPPT).
- Solar PV Inverters – These convert direct current (dc) to alternating current (ac).
- Monitoring Interface – This allows for module-level performance monitoring and energy yield assessment.

Power optimizers are installed by system integrators or installers and are connected to two PV modules. Each optimizer runs an MPPT algorithm that maintains its corresponding modules at the maximum power point. This approach can increase total system energy yield by mitigating power losses associated with module mismatch, non-uniform degradation, or partial shading.

Implementing MPPT at the module level also allows for increased flexibility in system design. Systems can include strings with different orientations, tilt angles, and module types. The inverter maintains the overall string voltage at a constant value for dc-ac conversion, regardless of string length (within allowable limits) or environmental conditions. This fixed voltage architecture enables the use of unequal string lengths and supports module placement on multiple roof surfaces, improving the use of available space.

Maintaining a constant string voltage also allows the inverter design to be optimized for high conversion efficiency at that specific voltage level. SolarEdge coordinates the design of its inverters with the characteristics of its power optimizers to take advantage of this system architecture.

One key functional benefit of the SolarEdge power optimizer is its ability to ensure that each module operates at its own individual maximum power point. This helps compensate for various operating condition differences within the same string, including partial shading, soiling, non-uniform module aging, or differences in temperature. Because the inverter receives a fixed dc voltage, it can operate more efficiently.

Other advantages of this system design include enhanced safety features and the capability to monitor the performance of each module in detail. The power optimizers continuously monitor and transmit module-specific performance data. This data is sent to the inverter using power line communication (PLC) over the existing DC string wiring. The inverter includes an integrated communication gateway with multiple connectivity options, enabling the data to be uploaded to a remote monitoring server.

The inverters are responsible for converting the dc power from the optimizer strings to ac power that is compatible with the utility grid. These inverters are required to meet various grid interconnection standards, which differ by region.

The overall efficiency of a SolarEdge-based PV system is determined by the combined performance of the power optimizers and the inverter.

Subsequent sections of this report will examine the individual performance and characteristics of the optimizer and inverter products used in the TerraMax family of products, as well as provide a discussion of overall system performance.

3.1 Product overview

This section provides a summary and general overview of the H-series optimizers and the TerraMax series PV inverters under review.

3.1.1 Power Optimizers

The SolarEdge H1300 and H1500 power optimizers are part of the company's latest generation of module-level power electronics (MLPE) developed for large-scale PV systems, particularly ground-mounted installations. A picture of these models is shown in Figure 3-3. These models are targeted for the global market, where they are intended to meet utility-scale design requirements and environmental conditions. The inclusion of region-specific certifications and compatibility with 1500 Vdc system architecture underscores their suitability for commercial and utility-scale applications globally.

Figure 3-3 Picture of SolarEdge's H-series power optimizer

These power optimizers are designed to be connected to two series-connected PV modules. Their primary function is to perform independent MPPT for the series pair of modules, thereby enhancing energy capture in the presence of module mismatch. This mismatch may be caused by partial shading, differences in module aging or orientation, or variations in irradiance. By performing MPPT at the module level, the system is able to maintain consistent and optimized power output across all modules, independent of localized performance deviations.

Another integral function of these power optimizers is their role in system safety. In the event of an inverter shutdown or grid disconnection, the optimizers are designed to reduce the string voltage to a safe level automatically. This feature, referred to as SafeDC™, limits the voltage at each optimizer's output to approximately 1 V, reducing the risk of electrical hazards during maintenance or emergency response situations.

The H1300 and H1500 models are engineered to support longer string lengths, allowing greater flexibility in PV array layout and reduced balance-of-system (BoS) costs. This includes a lower requirement for combiner boxes, fuses, and cabling. The longer strings also enable more efficient use of available land and simplify the electrical design in high-capacity installations.

Both models integrate with SolarEdge's monitoring platform, providing real-time, module-level data for performance tracking and remote troubleshooting. This level of visibility facilitates early detection of operational anomalies, streamlines maintenance, and reduces the need for on-site interventions. Communication between the optimizers and the inverter is handled via power line communication (PLC), which eliminates the need for additional communication wiring.

These optimizers are housed in enclosures rated for outdoor installation, with protection against dust, water ingress, and temperature extremes. Their physical design allows for mounting using standard PV module rails, which simplifies installation and ensures compatibility with typical site layouts. Some key features of the optimizers include:

- Designed for ground-mount PV systems in utility and commercial-scale applications
- Compatible with 1500 Vdc system architecture
- Performs MPPT at the module level to improve energy yield under non-uniform conditions
- Built-in SafeDC™ functionality for enhanced system safety during shutdowns
- Supports extended string lengths for reduced system complexity and lower balance-of-system costs
- Enables real-time, module-level performance monitoring and remote diagnostics
- Integrates seamlessly with SolarEdge inverters, including SE250KUS, SE285KUS, SE330KUS, and TerraMax SE300K/SE330K
- Suitable for high-power modules, including bifacial and G12 formats (H1500)
- Outdoor-rated enclosure with high environmental protection for long-term durability

The design emphasis is aimed towards scalability, safety, and ease of operation over the full system lifecycle.

3.1.2 TerraMax Series PV Inverters – SE330KUS, SE250KUS, SE285KUS, SE330K, and SE300K

The SolarEdge TerraMax series of inverters is developed for utility-scale and large commercial photovoltaic installations. Rendering of the TerraMax series inverters for North American Market (NAM) and European Union (EU) as well as Rest of the World (ROW) are shown in Figure 3-4. Designed for deployment in diverse environments—including agricultural fields, floating PV systems, and ground-mounted community solar arrays—these inverters are tailored to meet the requirements of high-capacity PV installations across both North America and international markets. North American models operate at either 600 Vac (SE250KUS, SE285KUS) or 690 Vac (SE330KUS), while models such as SE300K and SE330K are 690 Vac and configured for international grid standards.

(a) (b)

Figure 3-4 Picture of SolarEdge's TerraMax PV inverter for (a) NAM, (b) EU and ROW

The TerraMax platform uses a virtual central inverter topology with a single dc input architecture. It is designed for seamless integration with SolarEdge's module-level power optimizers, enabling distributed MPPT at the module level while centralizing the dc-to-ac conversion process. With support for up to 80 modules per string, the TerraMax system aims to reduce cable runs, junction boxes, and fusing components.

These inverters are capable of operating with dc oversizing up to 200% of the rated ac output power. This feature provides flexibility in array-to-inverter power ratios and can support energy capture from high-density PV fields or from bifacial modules under conditions of high irradiance or albedo. Additionally, the TerraMax inverters are designed to deliver full rated ac power even at ambient temperatures up to 45°C, with power derating applied only at higher temperatures. A pre-commissioning capability is built into the system, allowing optimizer as well as inverter validation and setup to be initiated directly from PV module power before grid connection, which has potential to reduce project delays during the commissioning phase.

These inverters incorporate integrated module-level optimization and provide system-wide monitoring and diagnostics. Communication interfaces include RS485, CAN bus, Ethernet, Wi-Fi, and optional cellular connectivity. This allows remote monitoring, rapid troubleshooting, and improved fleet management via the SolarEdge monitoring platform.

Safety and grid compliance are key design features. TerraMax inverters include built-in SafeDC functionality, which reduces dc voltage to safe levels during grid or inverter shutdown, enhancing safety for installers and maintenance personnel. The inverters also support a range of grid support and fault response features, such as fault ride-through related to low/high voltage ride-through, Volt-Watt, and Frequency-Watt modes, and reactive power control. Some key features include:

- Developed for utility-scale and large commercial PV systems
- Available for both North American (600 Vac and 690 Vac) and international markets
- Integrates with SolarEdge power optimizers for module-level MPPT and string-level simplicity
- Virtual central topology with single dc input architecture
- Supports 200% dc oversizing for high power density array designs

- Capable of full rated output at high ambient temperatures up to 45°C
- Pre-commissioning supported via module power for faster setup
- Advanced system safety with SafeDC functionality and integrated dc disconnects
- Multiple communication protocols for monitoring and fleet management
- Grid code compliance with voltage and frequency ride-through, reactive power control, and power factor adjustability
- IP66-rated enclosures and cooling systems suitable for outdoor environments

The TerraMax inverter family is engineered for scalable deployment in distributed and centralized configurations, which aims to reduce lifecycle costs, improve operational transparency, and maintain safety and grid compatibility throughout the system's operational life.

3.2 Inverter topology

A photovoltaic (PV) inverter plays a central role within any solar power generation system. Its primary function is to convert the dc electricity produced by solar modules into ac electricity, which is compatible with the utility grid or can be used directly by electrical loads. This dc-to-ac conversion process is essential because most electrical infrastructure and appliances operate on ac power, while solar panels inherently generate dc output. In addition to power conversion, the PV inverter is responsible for optimizing the energy yield from the solar array through features such as MPPT. MPPT ensures that each module or string of modules operates at its optimal voltage and current levels, maximizing energy harvest under varying environmental conditions such as shading, irradiance, and temperature. In case of SolarEdge inverters, the MPPT function is performed by module level devices referred to as Optimizers.

Modern PV inverters are also equipped with grid interaction functionalities. They actively regulate output voltage and frequency to match grid standards, ensuring safe and compliant interconnection. Many inverters also support advanced grid support features, such as reactive power control, voltage and frequency ride-through, and dynamic power factor adjustment, which enhance the overall stability and reliability of the electrical grid. Furthermore, PV inverters often include integrated communication interfaces that enable system-level monitoring, diagnostics, and control. These capabilities are valuable for operations and maintenance, enabling remote oversight and rapid fault identification, especially in large-scale or distributed PV installations. In summary, a PV inverter serves as the critical interface between the solar generation source and the electrical grid or end-user system. It not only facilitates efficient energy conversion but also contributes to system optimization, regulatory compliance, and grid stability, making it an indispensable component in any solar power system.

The internal architecture of the TerraMax series PV inverters is shown in Figure 3-5. The diagram outlines the main power conversion path along with key protection and control components integrated within the inverter. The dc power from the PV array enters the inverter through positive (DC+) and negative (DC–) terminals. The first stage includes a dc Surge Protection Device (DC SPD), which safeguards the inverter against voltage spikes induced by lightning or switching transients. Immediately following this is a dc switch, used to safely disconnect the PV input during maintenance or fault conditions. The dc power then passes through a Ground Fault Protector (GFP) and a dc Electromagnetic Interference (EMI) filter. The GFP monitors for unintentional paths to ground and initiates a trip if a fault is detected. The dc EMI filter suppresses high-frequency noise that may be generated by switching components or transmitted from the array. DC bus capacitors, referred as Bulk capacitors, follow next in the sequence. These components serve as energy buffers, stabilizing the dc voltage and supporting the operation of the downstream inverter bridge. The inverter circuit converts the stabilized dc power into ac using high-frequency switching. The topology of the inverter is Multilevel Active Neutral Point Clamped (ANPC) 3-phase inverter with hybrid IGBT-SiC technology as switching devices. A Multilevel ANPC 3-phase inverter with hybrid IGBT–SiC technology combines the efficiency benefits of multilevel topologies with the high-speed switching and low-loss characteristics of wide bandgap semiconductors. In this architecture, IGBTs are typically used for low-frequency switching and voltage blocking, while SiC MOSFETs handle high-frequency transitions, enabling reduced switching losses, lower thermal stress, and improved power density. The ANPC configuration also helps distribute voltage stress across devices, improving overall reliability and allowing operation at higher voltages with lower total harmonic distortion (THD). DNV views the topology positively.

Once the ac power is generated, it passes through a relay stage, which acts as a grid-interactive disconnect mechanism. The relay allows the inverter to disconnect from the grid when required, such as during faults or anti-islanding events. Downstream of the relay is a Residual Current Device (RCD), which provides leakage current detection to enhance user safety and meet regulatory standards. The ac output is then processed by an ac EMI filter, which reduces conducted noise before export to the grid. A second ac SPD is positioned at the output to protect the inverter and downstream systems from ac-side voltage surges. The entire system is monitored and coordinated by a control circuit, which manages switching operations, fault detection, system status, and communication. It interfaces with safety devices such as the RCD and relay and communicates externally via ports labeled Com1 and Com2. The inverter delivers three-phase ac output across lines L1, L2, and L3, completing the power conversion and grid interface process. This topology reflects a comprehensive approach to power conversion, safety, and electromagnetic compliance in modern PV inverter design.

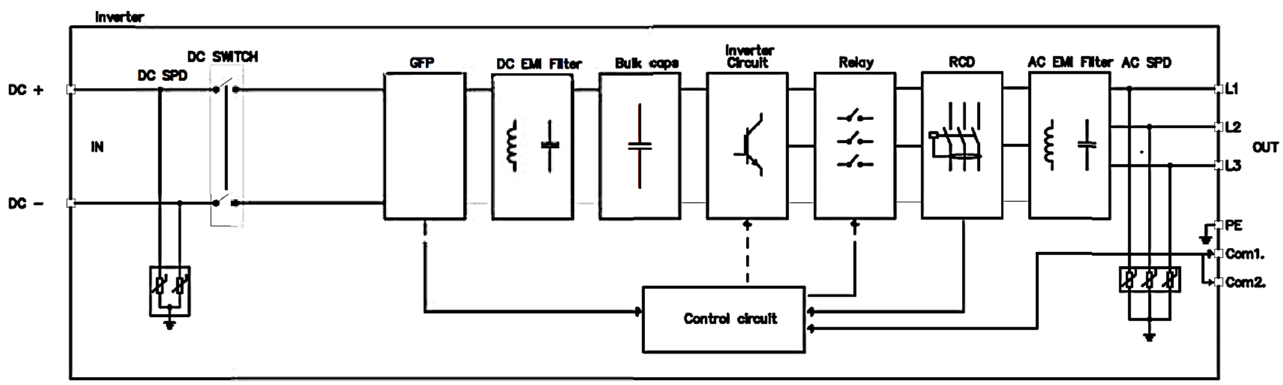

Figure 3-5 Architecture of SolarEdge TerraMax series PV inverters

SolarEdge H-series power optimizers are module-level dc-dc converters that operate alongside series-connected two PV modules to perform MPPT at the module level. This functionality allows the pair of modules to operate independently at its optimal power point, minimizing losses caused by shading, mismatch, or varying orientations across the array. By conditioning the output of each module, the optimizers maintain consistent power delivery to the inverter, improving overall system performance and design flexibility. In addition to energy optimization, these devices allow enhanced system safety by automatically reducing the dc voltage of each module to safe levels during inverter shutdown or grid disconnection. They also support module-level monitoring by transmitting performance data to the inverter using power line communication, which aids in fault detection and operational diagnostics. The configuration of the system and connection of the power optimizers H1300 is shown in Figure 3-6. The H1500 optimizer is also configured in a similar fashion.

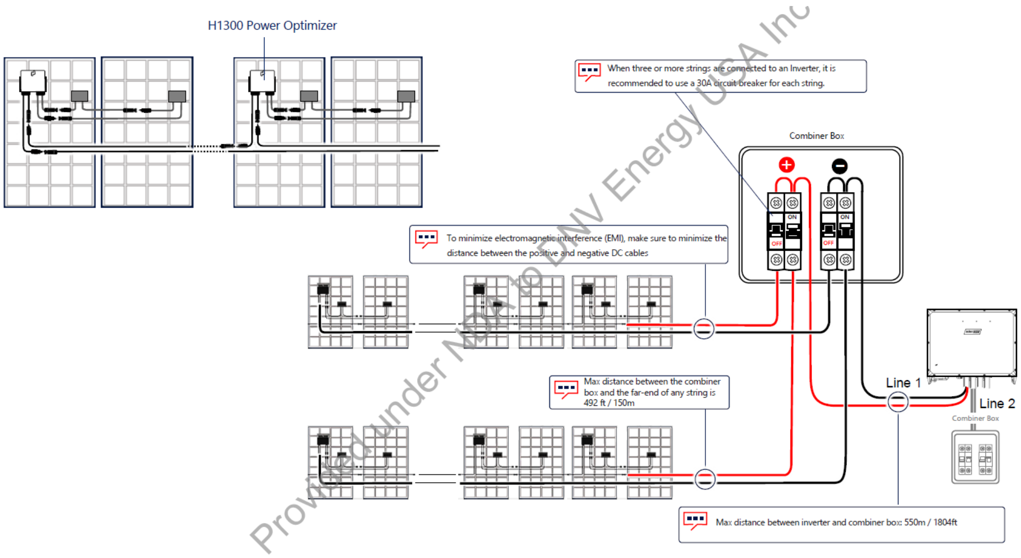

Figure 3-6 Configuration of SolarEdge power optimizer H1300 with TerraMax PV inverter

The SolarEdge TerraMax series inverters are designed as a central component within a modular PV system architecture, supporting large-scale solar installations. They utilize a transformerless, ungrounded topology that performs dc-to-ac power conversion while managing voltage and current inputs from multiple PV strings. It is capable of interfacing with multiple PV arrays through dedicated dc inputs and a combiner box, which aggregates the outputs of several module-level optimizers.

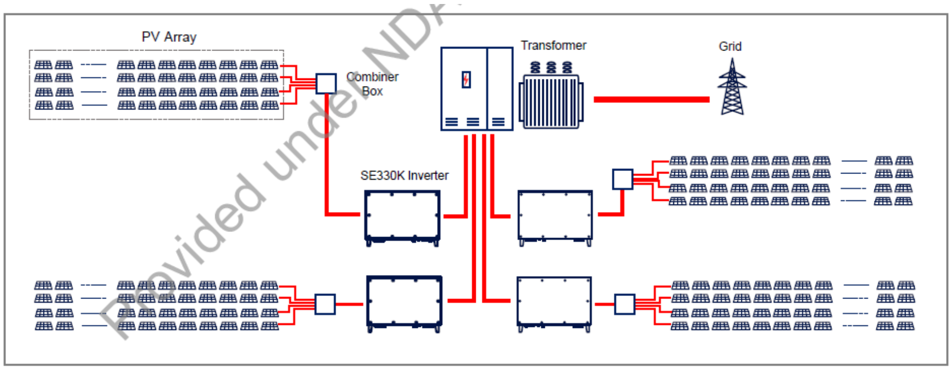

Figure 3-7 Full system architecture in one possible configuration using TerraMax PV inverters

The architecture possible using the TerraMax series PV inverters is shown in Figure 3-7. At the system level, the architecture comprises of two PV modules connected to each SolarEdge power optimizer. These optimizers feed into strings that can converge at a combiner box that connects to a TerraMax inverter (as shown in Figure 3-7). The Terramax series inverters support centralized architecture (as shown in Figure 3-7), as well as distributed architecture with inverters located next to the strings and combiner boxes. The inverter then processes the incoming dc power and converts it into three-phase ac power suitable for grid export or on-site consumption. The inverter is connected to the grid through a step-up transformer to match utility voltage levels. Communication between the inverter and system monitoring platforms is enabled through shielded CAT5e or CAT6 twisted-pair cables, supporting real-time performance data acquisition and control signals.

The electrical design accommodates long distances between system components—up to 150 meters from the far end of the PV string to the combiner box and up to 550 meters between the combiner box and the inverter. To reduce EMI, the layout emphasizes keeping dc cable runs (positive and negative) as close as possible. AC output terminals are configured for three-phase wiring, with specified conductor sizes and insulation ratings to ensure thermal and electrical compliance. Grounding is achieved through appropriately sized protective earth conductors, and all terminations follow strict installation clearances and derating guidelines based on ambient temperature and environmental conditions. This integrated design allows the inverter to operate as the central hub for energy conversion, system protection, and communication.

3.3 Technical specifications

3.3.1 Power Optimizers

The SolarEdge H1300 and H1500 power optimizers are designed for integration into large PV systems, including ground-mounted, floating, and agrivoltaic (agri-PV) installations. These devices function as module-level dc-dc converters, enabling independent MPPT for two series-connected PV modules per optimizer. This architecture supports improved system performance under conditions of module mismatch, shading, or varying orientations.

The H1300 is rated for an input dc power of 1300 W and supports modules with up to 650 W of rated output. It accepts a maximum input voltage of 125 Vdc and operates effectively across an MPPT voltage window of 12.5 to 105 Vdc. It is rated for a maximum continuous input current of 15 Adc, with a short circuit safety-adjusted threshold of 18.75 Adc. SolarEdge is actively working on increasing the short circuit limit to 20Adc. During normal operation, the H1300 provides up to 20 Adc output at 75 Vdc. When disconnected from the inverter or during grid shutdown, the optimizer limits its output to approximately 1 Vdc for safety. The unit achieves a maximum efficiency of 99.5% and a weighted efficiency of 98.8%.

The H1500 model is similar in design but intended for higher power modules, including bifacial and large-format (e.g., G12 cell size) modules. It supports an input dc power rating of 1500 W and allows for module input currents up to 20 Adc, with an adjusted short circuit threshold of 25 Adc. Like the H1300, it operates between 12.5 and 105 Vdc MPPT range, with a maximum input voltage of 125 Vdc. The H1500 outputs up to 24 Adc at 80 Vdc and also provides 1 Vdc in standby mode for safety. Its efficiency values match those of the H1300, with a maximum of 99.5% and a weighted value of at least 98.8%.

The SolarEdge H1300 power optimizer for European and international markets shares its fundamental architecture and functionality with the H1300 unit offered in North America but is adapted for compatibility with international grid codes, installation practices, and inverter configurations. Like its North American counterpart, the international H1300 performs module-level dc optimization through integrated MPPT and is designed to be connected to either one or two series-connected PV modules. A key distinction lies in inverter compatibility. While the North American H1300 is paired with inverter models such as SE250KUS, SE285KUS, and SE330KUS operating at 600 or 690 Vac and compliant with North American safety and grid interconnection standards (e.g., UL 1741, CSA C22.2), the H1300 for international markets is designed to integrate with SolarEdge TerraMax inverter models SE300K and SE330K. These inverters operate at 690 Vac and are certified to international standards, including IEC 62109 and grid codes such as VDE-AR-N 4110/4120 and EN 50549-2, among others. This distinction in inverter compatibility ensures adherence to regional regulatory and grid requirements. SolarEdge is also in process of making the H1300 for international markets compatible for integration with SE285K 600Vac model for Taiwan market.

Electrically, both versions of the H1300 share the same nominal specifications. The environmental specifications are also same between the models. However, connector types and cable lengths may vary slightly to align with regional standards or installation practices, such as the use of MC4-Evo2 connectors in international variants.

The detailed technical specifications for the H1300 and H1500 power optimizers are presented in Table 3-1, Table 3-2, and Table **3**-**3**. Both models are rated for operation in 1500 Vdc systems and are compatible with SolarEdge Terramax inverters. They are supplied with MC4 or MC4-Evo2 connectors and pre-terminated input/output leads of various lengths. The enclosures are IP68/NEMA6P rated, allowing for reliable outdoor use in a wide range of environmental conditions, including relative humidity from 0 to 100% and temperatures ranging from -40°C to +65°C. For ambient temperatures above 65°C, power derating must be considered.

In terms of system integration, the H1300 allows for string lengths of up to 40 optimizers (80 modules) with continuous string power up to 25 kW and maximum allowed connected string power up to 33 kW, depending on the inverter string count. The H1500 supports higher string capacities—up to 30 kW continuous and 40 kW maximum—accommodating string configurations with modules up to 750 W. Design requirements also include constraints on minimum and maximum string lengths based on module ratings and ensuring that the difference in the number of optimizers across strings connected to the same inverter does not exceed five units.

Both devices meet standards such as UL 1741, CSA C22.2 #107.1 and #330, VDE-AR-E 2100-712:2013-05, and are constructed with fire-resistant, UV-stable materials rated UL 94 V-0. Communication for module-level monitoring is achieved through SolarEdge's proprietary power line communication (PLC) protocol, utilizing existing dc wiring for data transfer to the inverter. These technical features support both performance optimization and safety in utility-scale solar energy systems.

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Table 3-1 Technical specifications of H1500 power optimizer

	H1500	Units
INPUT		
Rated Input DC Power(1)	1500	W
Connection Method	Single input for series connected modules	
Absolute Maximum Input Voltage (Voc at lowest temperature)	125	Vdc
MPPT Operating Range	12.5 – 105	Vdc
Maximum Short Circuit Current per Input (Isc)	20	Adc
Maximum Adjusted Short Circuit Current (with safety factor)(2)	25	Adc
Maximum Efficiency	99.5 or higher	%
Weighted Efficiency	98.8 or higher	%
Overvoltage Category	II	
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER)		
Maximum Output Current	24	Adc
Maximum Output Voltage	80	Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM OPERATING SOLAREDGE INVERTER)		
Safety Output Voltage per Power Optimizer	1 ± 0.1	Vdc
STANDARD COMPLIANCE(3)		
EMC	FCC Part 15 Class A	
Safety	UL 1741; CSA C22.2#107.1; CSA C22.2#330	
Material	UL 94 V-0, UV resistant	
RoHS	Yes	
Fire Safety	VDE-AR-E 2100-712:2013-05	
INSTALLATION SPECIFICATIONS		
Compatible SolarEdge Inverters	SE330KUS; SE250KUS; SE285KUS	
Maximum Allowed System Voltage	1500	Vdc
Dimensions (W x L x H)	129 x 155 x 59 / 5.08 x 6.10 x 2.32	mm / in
Weight (including cables)	1170 / 2.6	g / lb
Input / Output Connector(4)	MC4	
Input Wire Length	1.8, 1.8 / 5.9, 5.9	m / ft
Output Wire Length	0.1, 5.7 / 0.32, 18.7	m / ft
Operating Temperature Range(5)	-40 to 65 / -40 to 149	°C / °F
Protection Rating	IP68 / NEMA6P	
Relative Humidity	0 – 100	%

(1) The rated power of the module at STC will not exceed the power optimizer's Rated Input DC Power. Modules with up to +5% power tolerance are allowed.
(2) Adjusted for ambient temperature, irradiance, bifacial gain, safety factor, and so on, in accordance with NEC and CSA.
(3) Certification pending.
(4) For other connector types please contact SolarEdge.
(5) For ambient temperatures above +65°C / 149°F power derating is applied. Refer to the Temperature Derating technical note for details.

PV System Design Using a SolarEdge Inverter		SE330KUS / SE250KUS / SE285KUS	
Minimum String Length (Power Optimizers/Modules)		21 / 42	
Maximum String Length (Power Optimizers/Modules)	Module Power		
	580 – 600W	33 / 66	
	605 – 650W	31 / 62	
	655 – 700W	29 / 58	
	705 – 750W	27 / 54	
Maximum Continuous Power per String		30,000	W
Maximum Allowed Connected Power per String(6)		40,000	W
Maximum Allowed Difference between the shortest and longest string connected to the same inverter		5 Power Optimizers	

(6) For the SE250KUS, a minimum of 9 strings must be connected. For 8 strings or less, the Maximum Allowed Connected Power per String is 35,000W.
For the SE285KUS, a minimum of 10 strings must be connected. For 9 strings or less, the Maximum Allowed Connected Power per String is 35,000W.
For the SE330KUS, a minimum of 11 strings must be connected. For 10 strings or less, the Maximum Allowed Connected Power per String is 35,000W.

Table 3-2 Technical specifications of H1300 power optimizer for NAM

	H1300 (FOR CONNECTION TO TWO PV MODULES)	Units
INPUT		
Rated Input DC Power[1]	1300	W
Connection Method	Single input for series connected modules	
Absolute Maximum Input Voltage (Voc at lowest temperature)	125	Vdc
MPPT Operating Range	12.5 – 105	Vdc
Maximum Short Circuit Current per Input (Isc)	15	Adc
Maximum Adjusted Short Circuit Current (with safety factor)[2]	18.75	Adc
Maximum Efficiency	99.5	%
Weighted Efficiency	98.8	%
Overvoltage Category	II	
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER)		
Maximum Output Current	20	Adc
Maximum Output Voltage	75	Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM OPERATING SOLAREDGE INVERTER)		
Safety Output Voltage per Power Optimizer	1 ± 0.1	Vdc
STANDARD COMPLIANCE		
EMC	FCC Part 15 Class A	
Safety	UL 1741; CSA C22.2#107.1; CSA C22.2#330	
Material	UL 94 V-0, UV resistant	
RoHS	Yes	
Fire Safety	VDE-AR-E 2100-712:2013-05	
INSTALLATION SPECIFICATIONS		
Compatible SolarEdge Inverters	SE330KUS; SE250KUS; SE285KUS	
Maximum Allowed System Voltage	1500	Vdc
Dimensions (W x L x H)	129 x 155 x 59 / 5.08 x 6.10 x 2.32	mm / in
Weight (including cables)	1170 / 2.6	g / lb
Input / Output Connector[3]	MC4	
Input Wire Length	1.6, 1.6 / 5.25, 5.25	m / ft
Output Wire Length	0.1, 5.3 / 0.32, 17.39	m / ft
Operating Temperature Range[4]	-40 to 65 / -40 to 149	°C / °F
Protection Rating	IP68 / NEMA6P	
Relative Humidity	0 – 100	%

(1) The rated power of the module at STC will not exceed the power optimizer's Rated Input DC Power. Modules with up to +5% power tolerance are allowed.
(2) Adjusted for ambient temperature, irradiance, bifacial gain, safety factor, and so on, in accordance with NEC and CSA.
(3) For other connector types please contact SolarEdge.
(4) For ambient temperatures above +65°C / 149°F power derating is applied. Refer to the Temperature Derating technical note for details.

PV System Design Using a SolarEdge Inverter		SE330KUS / SE250KUS / SE285KUS	
Minimum String Length[5] (Power Optimizers/Modules)	Module Power		
	400 – 450W	27 / 54	
	455 – 550W	24 / 48	
	555 – 650W	22 / 44	
Maximum String Length (Power Optimizers/Modules)		40 / 80	
Maximum Continuous Power per String		25,000	W
Maximum Allowed Connected Power per String[6]		33,000	W
Maximum Allowed Difference between the shortest and longest string connected to the same inverter		5 Power Optimizers	

(5) Design your project using SolarEdge Designer use a lower minimum string length and/or connect more STC power per string.
(6) For the SE250KUS, a minimum of 10 strings must be connected. For 9 strings or less, the Maximum Allowed Connected Power per String is 29,000W.
For the SE285KUS, a minimum of 12 strings must be connected. For 11 strings or less, the Maximum Allowed Connected Power per String is 29,000W.
For the SE330KUS, a minimum of 14 strings must be connected. For 13 strings or less, the Maximum Allowed Connected Power per String is 29,000W.

Table 3-3 **Technical specifications of H1300 power optimizer for European and International markets**

	H1300	Units
INPUT		
Rated Input DC Power(1)	1300	W
Connection Method	Single input for series connected modules	
Absolute Maximum Input Voltage (Voc at lowest temperature)	125	Vdc
MPPT Operating Range	12.5 – 105	Vdc
Maximum Continuous Input Current	15	Adc
Maximum Short Circuit Current (Isc) of Connected PV Module	18.75	Adc
Maximum Efficiency	99.5	%
Weighted Efficiency	98.8	%
Overvoltage Category	II	
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER)		
Rated Output Current	20	Adc
Rated Output Voltage	75	Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR INVERTER OFF)		
Safety Output Voltage per Power Optimizer	1 ± 0.1	Vdc
STANDARD COMPLIANCE		
EMC	FCC Part 15 Class A, IEC 61000-6-2, IEC 61000-6-4, EN 55011	
Safety	IEC 62109-1 (Class II safety)	
Material	UL94 V-0, UV resistant	
RoHS	Yes	
Fire Safety	VDE-AR-E 2100-712:2013-05	
INSTALLATION SPECIFICATIONS		
Compatible SolarEdge Inverters	SolarEdge TerraMax™ Inverter SE300K and SolarEdge TerraMax™ Inverter SE330K	
Maximum Allowed System Voltage	1500	Vdc
Dimensions (W x L x H)	129 x 155 x 59 / 5.08 x 6.10 x 2.32	mm / in
Weight (including cables)	1170 / 2.6	g / lb
Input Connector	MC4-Evo2(2)	
Input Wire Length	0.16, 0.16 / 0.52, 0.52	m / ft
Output Connector	MC4-Evo2	
Output Wire Length	0.1, 5.3 / 0.32, 17.39	m / ft
Operating Temperature Range(3)	-40 to +65 / -40 to +149	°C / °F
Protection Rating	IP68 / NEMA6P	
Relative Humidity	0 – 100	%

(1) The rated power of the module at STC will not exceed the power optimizer's Rated Input DC Power. Modules with up to +5% power tolerance are allowed.
(2) For other connector types please contact SolarEdge.
(3) For ambient temperatures above +65°C / 149°F power derating is applied. Refer to the Temperature Derating technical note for more details.

		SE300K	SE330K	Units
Minimum String Length(4) (Power Optimizers/Modules)	**Module Power**			
	400 – 450W	27 / 54	27 / 54	
	455 – 550W	24 / 48	24 / 48	
	555 – 650W	22 / 44	22 / 44	
Maximum String Length (Power Optimizers/Modules)		40 / 80	40 / 80	
Maximum Continuous Power per String		25,000	25,000	W
Maximum Allowed Connected Power per String		33,000(5)	33,000(6)	W
Maximum allowed difference between the shortest and longest string connected to the same inverter		5 Power Optimizers		

(4) Design your project using SolarEdge Designer to use a lower minimum string length and/or connect more STC power per string.
(5) For the SE300K, a minimum of 12 strings must be connected. For 11 strings or less, 29,000W is allowed.
(6) For the SE330K, a minimum of 14 strings must be connected. For 13 strings or less, 29,000W is allowed.

3.3.2 TerraMax Series PV Inverters

The SolarEdge TerraMax series of PV inverters is designed for utility-scale and large commercial installations, featuring transformerless, ungrounded topology and compatibility with 1500 Vdc systems. These inverters operate at high ac voltages, with variants supporting both 600 Vac and 690 Vac nominal outputs, depending on regional grid requirements. The product line includes models such as SE250KUS, SE285KUS, and SE330KUS for North America Market (NAM), and

SE300K and SE330K for European and international markets. The detailed technical specifications for NAM-targeted models are presented in Table 3-4 and Table 3-5. The technical specifications for models targeted towards European and international markets are presented in Table 3-6.

All TerraMax inverters are configured with a virtual central topology that consolidates power conversion into a centralized unit while enabling module-level optimization through SolarEdge power optimizers. The input architecture is based on a single dc input with support for long strings—up to 80 modules per string—reducing the number of strings, cables, and balance-of-system components. On the dc side, the inverters support a maximum input voltage of 1500 Vdc and a nominal input voltage of 1250 Vdc. The rated input current varies by model, with values up to 266.7 Adc for the higher-capacity SE330KUS and SE330K models. These systems allow for substantial dc oversizing—up to 200% of the ac rating—enabling more energy capture during peak solar conditions.

On the ac output side, the inverters provide three-phase power with a nominal voltage of either 600 Vac or 690 Vac, depending on the specific variant. Frequency is region-specific, with 60 Hz supported in North American models and 50 Hz in international models. The continuous output current per phase for all models is approximately 276 Aac. Total harmonic distortion (THD) is kept below 3%, and the power factor is adjustable across the full range from 0.2 to 1 (leading) and 0.2 to 1 (lagging). The efficiency of TerraMax inverters is high, with maximum efficiency reaching 99.2% and weighted (CEC or EU) efficiencies ranging between 98.8% and 99.0%, depending on the model. These performance levels are supported by integrated dc and ac surge protection (Type 2, monitored and replaceable), ground fault detection, reverse polarity protection, and integrated dc disconnect switches. The inverters also include residual current device and ac overcurrent protection for safety compliance.

Additional features include night-time potential-induced degradation (PID) protection via integrated rectifiers, pre-commissioning capability using module power, and centralized commissioning for multiple inverters. Communication options include CAN bus, RS485, Ethernet, Wi-Fi, and optional cellular connectivity. The inverters can be commissioned using the SetApp mobile application, which connects via a built-in Wi-Fi access point. The enclosure is IP66-rated for outdoor use and includes cooling fans. Operating temperature ranges from -40°C to +60°C, with power derating applied above 45°C.

Compliance with regional grid standards is incorporated into each model. North American variants meet UL 1741, UL 1998, IEEE 1547, and related state-level requirements (e.g., Rule 21 and Rule 14). European and international models conform to IEC 62109 safety standards, grid codes such as VDE-AR-N 4110/4120, and EMC requirements including CISPR 11 and EN 61000 series.

Table 3-4 Technical specifications for TerraMax PV inverter model SE330KUS

	SE330KUS	Unit
OUTPUT		
Rated AC Active Output Power	330,000 @ 45°C / 113°F	W
Maximum Apparent AC Power Output	330,000 @ 45°C / 113°F	VA
AC Output Voltage - Line to Line (Nominal)	690	Vac
AC Output Voltage - Line to Line (Range)	587 – 759	Vac
AC Frequency	60 ± 5%	Hz
Maximum Continuous Output Current (per Phase) @Nominal Voltage	276.1	Aac
AC Output Line Connections	3PH 3W + PE	
Total Harmonic Distortion	≤3	%
Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds	Yes	
Power Factor Range	0.2 – 1 / leading, lagging	
INPUT		
Maximum DC Power (Module STC)	660,000	W
Maximum Input Voltage DC+ to DC-	1500	Vdc
Nominal DC Input Voltage DC+ to DC-	1250	Vdc
Maximum Input Current	266.7	Adc
Module-Level Optimization	Yes	
EFFICIENCY		
Maximum Efficiency / CEC Efficiency	99.2 / 99.0	%
PROTECTION FEATURES		
DC Reverse Polarity Protection	Yes	
Ground Fault Isolation Detection	Yes	
AC Surge Protection	Type 2, monitored and field replaceable	
DC Surge Protection	Type 2, monitored and field replaceable	
CAN, RS485 Surge Protection	Yes	
DC Disconnect	Yes, integrated	
RCD Protection	Yes	
AC Overcurrent Protection	Yes	
ADDITIONAL FEATURES		
Supported Communication Interfaces	CAN bus; RS485; Ethernet; WiFi; Cellular (optional)	
PID Protection	PID Rectifier	
Inverter Commissioning	With the SetApp mobile application using built-in Wi-Fi access point for local connection	
Pre-Commissioning	Inverter activation and validation powered by PV modules	
Central Commissioning	Automated easy commissioning for several inverters at once	
VAR at Night	Yes	
STANDARD COMPLIANCE		
Safety	UL 1741; UL 1998; CSA C22.2#107.1	
Grid Connection Standards	UL 1741 SA; UL 1741 SB; IEEE 1547 Rule 21, Rule 14	
Emissions	FCC Part 15, Class A	
Advanced Grid Support Capabilities	L/HFRT; L/HVRT; VOLT-VAR; VOLT-Watt; Frequency-Watt; Ramp Rate Control; Fixed Power Factor; Fixed Q; Cos (Phi) / Watt	
RoHS	Yes	
GENERAL DATA		
Dimensions (W x H x D)	1090 x 914 x 416 / 42.9 x 35.9 x 16.4	mm / in
Weight	163/ 359	kg / lb
Operating Temperature Range(1)	-40 to +60 / -40 to +140	°C / °F
Cooling	Fans (field replaceable)	
Noise Emission	< 72	dBA
Protection Rating	IP66	
Mounting	Bracket provided	
Topology	Transformerless, ungrounded	
AC Connection(2)	Up to 2 x 2.5" conduit, terminal lugs, max. 600 kcmil per wire, Al or Cu	
DC Connection(3)	Up to 2 x 3" conduit, terminal lugs, max. 600 kcmil per wire, Al or Cu	

(1) For ambient temperatures above +45°C / 113°F power derating is applied. Refer to the Temperature Derating technical note for details.
(2) Two AC terminals per line are available.
(3) Up to two DC terminals (+, -) are available.

Table 3-5 Technical specifications for TerraMax PV inverter model SE250KUS and SE285KUS

	SE250KUS	SE285KUS	Units
OUTPUT			
Rated AC Active Output Power	250,000 @ 45°C / 113°F	285,000 @ 45°C / 113°F	W
Maximum Apparent AC Power Output	285,000 @ 45°C / 113°F	285,000 @ 45°C / 113°F	VA
AC Output Voltage - Line to Line (Nominal)	600		Vac
AC Output Voltage - Line to Line (Range)	510 – 660		Vac
AC Frequency	60 ± 5%		Hz
Maximum Continuous Output Current (per Phase) @Nominal Voltage	276.1		Aac
AC Output Line Connections	3PH 3W + PE		
Total Harmonic Distortion	≤3		%
Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds	Yes		
Power Factor Range	0.2 – 1 / leading, lagging		
INPUT			
Maximum DC Power (Module STC)	570,000	570,000	W
Maximum Input Voltage DC+ to DC-	1500		Vdc
Nominal DC Input Voltage DC+ to DC-	1250		Vdc
Maximum Input Current	203	231	Adc
Module-Level Optimization	Yes		
EFFICIENCY			
Maximum Efficiency / CEC Efficiency	99.2 / 99.0		%
PROTECTION FEATURES			
DC Reverse Polarity Protection	Yes		
Ground Fault Isolation Detection	Yes		
AC Surge Protection	Type 2, monitored and field replaceable		
DC Surge Protection	Type 2, monitored and field replaceable		
CAN, RS485 Surge Protection	Yes		
DC Disconnect	Yes, integrated		
RCD Protection	Yes		
AC Overcurrent Protection	Yes		
ADDITIONAL FEATURES			
Supported Communication Interfaces	CAN bus; RS485; Ethernet; WiFi; Cellular (optional)		
PID Protection	PID Rectifier		
Inverter Commissioning	With the SetApp mobile application using built-in Wi-Fi access point for local connection		
Pre-Commissioning	Inverter activation and validation powered by PV modules		
Central Commissioning	Automated easy commissioning for several inverters at once		
VAR at Night	Yes		
STANDARD COMPLIANCE			
Safety	UL 1741; UL 1998; CSA C22.2#107.1		
Grid Connection Standards	UL 1741 SA; UL 1741 SB; IEEE 1547, Rule 21, Rule 14		
Emissions	FCC Part 15, Class A		
Advanced Grid Support Capabilities	L/HFRT; L/HVRT; VOLT-VAR; VOLT-Watt; Frequency-Watt; Ramp Rate Control; Fixed Power Factor; Fixed Q; Cos (Phi) / Watt		
RoHS	Yes		
GENERAL DATA			
Dimensions (W x H x D)	1090 x 914 x 416 / 42.9 x 35.9 x 16.4		mm / in
Weight	163 / 359		kg / lb
Operating Temperature Range[1]	-40 to +60 / -40 to +140		°C / °F
Relative Humidity	0 – 100		%
Cooling	Fans (field replaceable)		
Noise Emission	< 72		dBA
Protection Rating	IP66		
Mounting	Bracket provided		
Topology	Transformerless, ungrounded		
AC Connection[2]	Up to 2 x 2.5" conduit, terminal lugs, maximum 600 kcmil per wire, Al or Cu		
DC Connection[3]	Up to 2 x 3" conduit, terminal lugs, maximum 600 kcmil per wire, Al or Cu		

(1) For ambient temperatures above 113°F / +45°C power derating is applied. Refer to the Temperature Derating technical note for details.
(2) Two AC terminals per phase are available.
(3) Up to two DC terminals (+, -) are available.

Table 3-6 Technical specifications for TerraMax PV inverter model SE300K and SE330K

	SE300K[1]	SE330K	Units
OUTPUT			
Rated AC Active Output Power	297,000 @ 45ºC	330,000 @ 45ºC	W
Maximum Apparent AC Output Power	297,000 @ 45ºC	330,000 @ 45ºC	VA
AC Output Voltage – Line to Line (Nominal)	690		Vac
AC Output Voltage – Line to Line (Range)	587 – 759		Vac
AC Frequency	50 ± 5%		Hz
Rated Continuous Output Current (per Phase) @Nominal Voltage	276.1		Aac
AC Output Line Connections	3W + PE		
Total Harmonic Distortion	≤3		%
Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds	Yes		
Power Factor Range	0.2 – 1 / leading, lagging		
INPUT			
Maximum DC Power (Module STC)	594,000	660,000	W
Maximum Input Voltage DC+ to DC-	1500		Vdc
Nominal DC Input Voltage DC+ to DC-	1250		Vdc
Maximum Input Current	266.7		Adc
Module-Level Optimization	Yes		
EFFICIENCY			
Maximum Efficiency / EU Efficiency	99.2 / 98.8		%
PROTECTION FEATURES			
DC Reverse Polarity Protection	Yes		
Ground Fault Isolation Detection	Yes		
AC Surge Protection	Type 2, monitored and field replaceable		
DC Surge Protection	Type 2, monitored and field replaceable		
CAN, RS485 Surge Protection	Yes		
DC Disconnect	Yes, integrated		
ADDITIONAL FEATURES			
Supported Communication Interfaces	CAN bus, RS485, Ethernet, WiFi, Cellular (optional)		
PID Protection	PID Rectifier		
Inverter Commissioning	With the SetApp mobile application using built-in Wi-Fi access point for local connection		
Pre-Commissioning	Inverter activation and validation powered by PV modules		
VAR at Night	Yes		
STANDARD COMPLIANCE			
Safety	IEC 62109		
Grid Connection Standards	VDE-AR-N 4110, VDE-AR-N 4120	EN 50549-2, C10/11, G99 Type A and B, CEI 0-16, NTS, TOR Erzeuger Typ B, C, D	
EMC	IEC/EN 61000-6-2, IEC 61000-6-4, EN 55011, CISPR 11, IEC 62920		
RoHS	Yes		
GENERAL DATA			
Dimensions (W x H x D)	1090 x 914 x 416 / 42.91 x 35.98 x 16.38		mm / in
Weight	175 / 386		kg / lb
Operating Temperature Range	-40 to +60 / -40 to +140[2]		°C / °F
Cooling	Fans (field replaceable)		
Noise Emission	< 72		dBA
Protection Rating	IP66		
Mounting	Bracket provided		
Topology	Transformerless		
AC Connection[3]	2 Glands, Cable Diameter 48 – 55mm, Terminal Lugs, Max. 300mm² per wire, Al or Cu		
DC Connection[4]	4 Glands, Cable Diameter 22 – 32mm, Terminal Lugs, Max. 300mm² per wire, Al or Cu		

(1) Available in DACH countries that follow VDE-AR-N-4110/VDE-AR-N-4120.
(2) For ambient temperatures above +45°C / 113°F power derating is applied. Refer to the Temperature Derating technical note for more details.
(3) Two AC terminals per line are available.
(4) Two sets of DC terminals (+, -) are available.

In PV inverters, power derating related to dc and ac voltage conditions refers to the intentional reduction of power output when voltage levels at the inverter's input or output deviate from specified operational thresholds. This behavior is implemented to protect internal components and ensure reliable and safe operation under varying environmental or electrical conditions.

DC Voltage Derating: On the dc side, the inverter receives power from the PV array, which can produce a wide range of voltages depending on factors such as solar irradiance, temperature, and array configuration. PV inverters are designed to operate within a defined dc voltage range. If the input voltage falls below the minimum threshold or rises near or beyond the upper voltage limit, the inverter may initiate power derating. This reduction in power output helps protect sensitive internal components, such as dc link capacitors and switching devices, from excessive electrical stress. Derating at high dc voltages prevents thermal overloading and minimizes the risk of damage or reduced component lifespan, while at low voltages, it ensures operation remains within the inverter's control and efficiency range.

AC Voltage Derating: On the ac side, the inverter must synchronize with the voltage and frequency of the utility grid or local electrical system. When the grid voltage rises above or falls below acceptable limits, the inverter may respond by decreasing its power output. This is necessary to comply with grid support standards and to avoid injecting power into a grid that is outside operational limits. AC voltage derating prevents overloading the grid connection point and avoids operational instabilities that can occur from mismatched voltage levels. It also serves as a protective response to prevent overcurrent conditions and ensure that inverter operation remains within regulatory voltage and frequency ranges.

The ac voltage dependent power derating for the Terramax series PV inverters is governed by the relation:

$$P_{out}(V_{LN}) = \min(3 * 276.1 * V_{LN}, 330000)$$

The ac voltage dependent power derating curve for SE330K and SE330KUS models is shown in Figure 3-8.

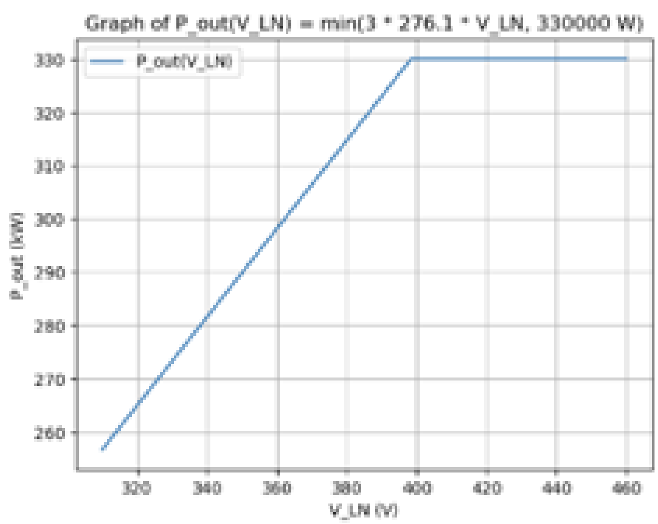


Figure 3-8 AC voltage dependent power derating curve for Terramax SE330 K and SE330KUS

3.4 Environmental characteristics

Understanding derating characteristics is crucial when performing system design, especially in locations with higher ambient temperatures where converters may derate below their maximum power rating. This section discusses the derating characteristics of the TerraMax PV inverters. Typically, system designers take these deratings into consideration during the project's design phase. DNV emphasizes the importance of closely monitoring these ratings for different locations of projects.

The SolarEdge TerraMax PV inverters are rated for operation from -40°C to 60°C. They are designed to operate at rated power up to 45°C. Beyond 45°C, derating is necessary, and the inverters can continue operating up to a maximum ambient temperature of 60°C, as shown in Figure 3-9. DNV finds the derating curve for the TerraMax inverter models to be leading compared to similar inverters in the market and are suitable for deployment in most locations across the globe. The H1300 and H1500 power optimizers are rated to operate from -40°C to 65°C ambient temperature without power derating.

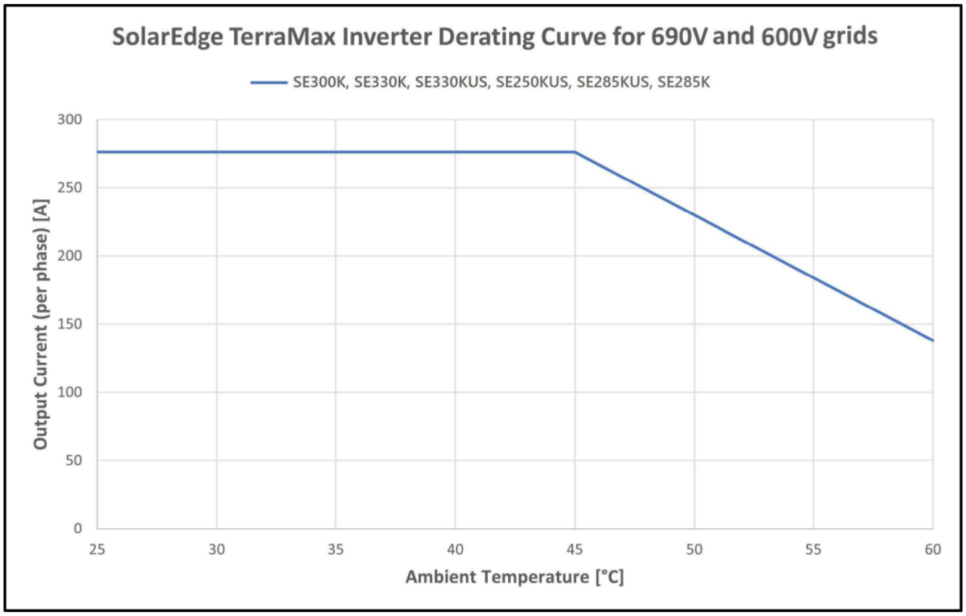


Figure 3-9 Ambient temperature dependent power derating curve for SolarEdge's TerraMax PV inverters

Both the SolarEdge TerraMax inverters and H1300/H1500 power optimizers feature enclosures rated for outdoor use with high protection against environmental factors. The inverters are rated IP66, indicating they are dust-tight and protected against powerful water jets, making them suitable for installation in exposed outdoor environments with varying weather conditions. The enclosure includes provisions for secure cable entry and internal airflow, supported by field-replaceable cooling fans. The power optimizers are rated IP68 / NEMA 6P, providing a higher level of protection. This rating certifies full protection against dust ingress and allows for prolonged submersion in water under specified conditions. These enclosures are designed to operate reliably in harsh field conditions, including areas with high humidity and exposure to dirt or standing water. According to DNV, the enclosure ratings for the inverters are leading for inverters of similar type in the market. The relative humidity rating for H1300 and H1500 optimizers is 0% to 100% non condensing. The PV inverters also have a relative humidity rating of 0% to 100%.

At higher altitudes, the lower air density affects both the heat dissipation capability and the dielectric rating of power electronic components. The elevation rating for rated power operation of SolarEdge TerraMax PV inverter series is 3000m. SolarEdge confirmed that there is no power derating up to 3000m. System designers are advised to collaborate with SolarEdge to establish protection and derating parameters based on their project requirements and the specific site conditions. DNV acknowledges that the environmental ratings of SolarEdge TerraMax series PV inverters are leading industry standards for an inverter of this size.

3.5 Project-specific power derating

Power deratings in inverters are typically configured through software settings, effectively limiting the converter's output power to a level below its maximum rated capacity. These deratings serve various purposes in different project scenarios:

- Grid Interconnect Limits: Power deratings can be imposed to ensure that the energy output from a project aligns with the constraints imposed by the grid interconnection. This ensures that the project operates within the capacity limits allowed by the grid infrastructure, preventing grid instability or overloading.
- Thermal Design Margin: Deratings may be applied to provide a thermal design margin. By limiting the power output, the converter can operate more comfortably in higher ambient temperature conditions without the risk of overheating.
- Predictable Power Output: Establishing fixed power deratings at the project level offers a more predictable power output profile. This predictability is especially valuable when compared to experiencing power deratings based on fluctuating weather conditions. It allows for better planning and management of the project's energy generation.

It is important to note that implementing fixed power deratings often requires the installation of additional converters to meet the project's energy projections, as the output of individual inverters is intentionally limited. This approach helps ensure the stability and reliability of the energy generation system.

3.6 Thermal Management System

The power optimizers use natural convection as thermal management system. The optimizers have Three temperature sensors:

- 1 x Power train temperature sensor
- 2 x cables temperature sensor

These temperature sensors ensure the optimizers work within required operating range and protect the power optimizer from exceeding internal temperature threshold.

The TerraMax inverter series includes an integrated thermal management system (TMS) designed to maintain operational stability and protect internal components from thermal overstress. It employs forced air as the cooling mechanism in the TMS. The system combines real-time temperature monitoring, a power derating mechanism, and fault detection across various heat-sensitive areas within the inverter.

Temperature sensors are placed on key internal components including power semiconductors switches, capacitors (input, filter, and gate driver), ac and dc terminals, and within the ambient internal environment. These sensors are used to continuously monitor thermal conditions during inverter operation.

Data from these sensors is used to evaluate whether internal temperatures remain within specified operational limits. In development and testing phases, simulations and measured temperature data are used to calibrate sensor responses and align them with expected in-field performance.

To avoid thermal overload, the inverter implements a power derating algorithm. The process involves:

- Identifying the highest temperature reading from each monitored component group.
- Calculating a derating ratio based on the component’s predefined operational range.
- Applying the most restrictive of these ratios to limit the inverter’s current reference.
- Adjusting output power based on this current limit via the inverter’s control system.

If any component group exceeds its thermal threshold and derating is insufficient to bring it back into range, the inverter will transition to standby mode. Operation resumes automatically once temperatures fall below recovery thresholds. For example, derating begins at 96°C for IGBTs and at 91°C for SiC devices (at the component level). Cooling is supported by a set of controlled fans. Fan operation is managed by the inverter's internal controller, which adjusts speed in response to temperature readings. Specific temperature points determine when fans start and reach full speed.

Fan RPM is monitored, and any deviation from expected performance—such as failure or insufficient rotation speed—is logged. The system records fan operational status and makes this information available for remote diagnostics. These features are included in production testing and system monitoring but also provide basic fault visibility in case of failures during operation.

The inverter includes thermal sensors near the ac and dc power terminals as shown in Figure 3-10. These sensors detect increases in connection temperature that could indicate high resistance due to loose or faulty wiring. The monitoring system evaluates both absolute temperatures and relative differences across terminals (e.g., DC+ versus DC-, or L1 versus L2/L3).

Three operational ranges are defined:

- Normal: no thermal irregularity detected.
- Warning: elevated temperatures suggest further inspection may be needed.
- Critical: temperature exceeds allowable limits and the inverter is locked.

When a critical thermal condition is detected at a terminal, the inverter enters a locked state and ceases operation. This condition cannot be reset locally and requires a remote unlock command by authorized support personnel.

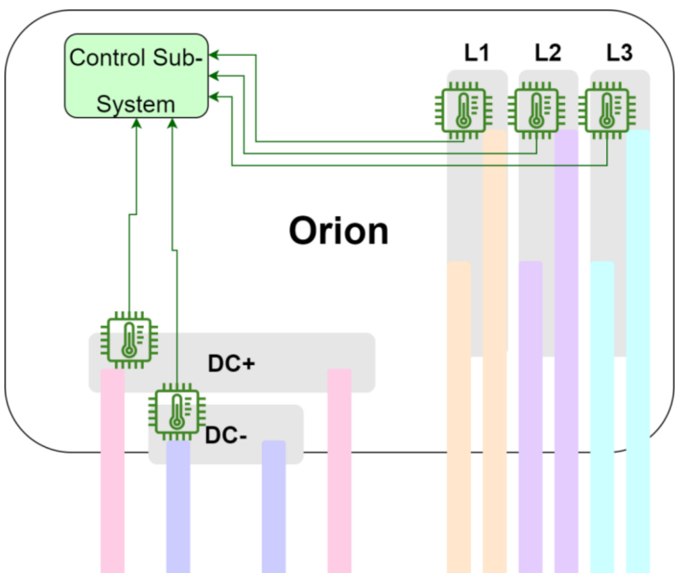


Figure 3-10 Temperature monitoring at input and output of the inverters

Temperature data from all relevant sensors is periodically collected and reported to the system's communications layer. Measurements are updated every five minutes and transmitted to the monitoring platform. If sensor readings fall outside valid ranges (e.g., below -40°C or above 125°C), they are excluded from fault or control decisions during that data cycle.

DNV views the TMS implemented in TerraMax PV inverters positively.

3.7 Power quality and grid support

This section provides a review of converter characteristics that affect the supplied power quality as well as inverter features that provide support to the ac grid. Power quality includes subjects of ac line harmonics, power factor, and dc current injection.

3.7.1 Inverter power factor

Adjusting the phase angle of the current relative to the line voltage allows an inverter to easily provide current that is in phase with the line voltage. However, current and voltage are perfectly in phase at only one point along the power path; at other locations between the inverter's terminals and the utility, the phase angle varies due to circuit impedances.

An inverter delivers current at the specified phase angle, which means it can also provide current that is intentionally out-of-phase with the line voltage, producing reactive power (VARs). If unity power factor is desired, the closer the inverter operates to unity, the better the efficiency. However, when the need arises to source or sink reactive power, closed-loop control of the commanded VARs or power factor is preferred to maintain accuracy.

The sizing of most components in an inverter is determined by the current magnitude. When the inverter operates off unity power factor, more current is required. Since reactive current is orthogonal to real current, near-unity power factor operation typically requires only a slight increase in current, which can often be managed by reducing the real current without significant de-rating. On the other hand, operating at a low power factor requires substantially more current, often necessitating a reduction in the real current output to prevent overloading the inverter components.

The SolarEdge TerraMax series PV inverters support 0.2 – 1 power factor both in leading and lagging modes.

3.7.2 Inverter stated THD from datasheet/Measured THD

It is good to keep in mind that the magnitude of allowed harmonics is a percentage of the rated power. Therefore, large inverters can inject harmonics up to 5% of rated power. When installed for connection to a utility, these harmonics may be harmless, and the switching harmonics may tend to cancel-out when multiple inverters are installed. However, when a large inverter is connected to a facility with sensitive electronic equipment, the harmonics may find a way to disrupt or destroy small electronic devices.

IEEE 519 – Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems specifies the Total Harmonic Distortion (THD) at 5% or less for power producing equipment. Technically, the correct TLA is TDD (Total Demand Distortion) because the limit is referenced to the rated power level, so that even the percentage of harmonics at 33% power is the ratio of measured harmonics divided by rated power.

IEEE 519 does not give credit for sources with lower TDD measurements; however, the industry does seem to acknowledge that lower harmonics are a characteristic of a better inverter.

The datasheets of SolarEdge TerraMax series PV inverters have listed THD ≤ 3% at rated load. DNV also reviewed a test report issued by SGS that presented results of THD evaluation for the SE330K inverter model. The THD and TDD were evaluated per EN 50549 standards. For the SE330K inverter, the THD was measured and reported as follows:

- THD for current: Calculated based on the arithmetic average over 10-minute recordings at various output power levels (from 5% to 100% of nominal power).
- Maximum THD (as stated in datasheets and confirmed in testing): ≤3%.

This THD rating complies with grid interconnection standards and ensures compatibility with utility power quality requirements.

3.7.3 Measured dc current injection and requirement < 0.5%

DC injection is a phenomenon that can occur with inverters, and it arises because inverters have the capability to supply both ac and dc current. However, to ensure the safe and reliable operation of electrical systems, certain limits are imposed on the magnitude of injected dc current, as specified by UL 1741 requirements. The 0.5% limit on injected dc current is crucial for several reasons:

- Transformer Core Saturation: Injected dc current can flow into the secondary side of isolation transformers. If this dc current exceeds a certain threshold, it can saturate the transformer's core. When the transformer core saturates, it loses its ability to effectively transform the ac cycles, resulting in irregular and distorted output voltage and current waveforms.
- High Current Distortion: Core saturation in transformers disrupts their ability to provide a consistent ac cycle. This can lead to high levels of current distortion in the electrical system, negatively impacting the performance of connected devices and equipment.
- Safety and Compatibility: Adhering to the 0.5% limit ensures that the converter's output remains within safe and acceptable parameters. This prevents adverse effects on the electrical infrastructure and connected loads, promoting safety and compatibility.

Complying with the 0.5% limit on injected dc current is essential for maintaining the integrity and reliability of electrical systems powered by inverters.

DNV reviewed test report issued by SGS that recorded results for evaluation of dc current injection by SE330K PV inverter model. The dc current injection test for the SolarEdge SE330K inverter, conducted under EN 50549-2 compliance, confirmed that the inverter met the standard’s requirements. Measurements were taken at multiple output power levels (approximately 33%, 66%, and 100% of rated power), and in all cases, the average dc current injected into the grid remained below the allowable limit of 0.5% of the inverter’s rated current. Typical measured values ranged from 0.2% to 0.4% of nominal current across all three output phases. The results demonstrated that the inverter did not inject excessive dc current into the grid and therefore passed the dc injection compliance test.

3.7.4 Grid Support Functions

As PV and BESS become more prevalent within the overall power grid, the expectations and requirements for power converters are also advancing. These devices are now expected to exhibit high adaptability to changing grid conditions.

Grid Adaptability: Grid adaptability refers to a converter's ability to maintain stable operation under various grid conditions such as voltage fluctuations and frequency variations. As the grid integrates more renewable sources, which are inherently variable, the robustness of grid-tied devices like converters becomes crucial. This adaptability ensures not only the efficient operation of the converter but also aids in stabilizing the grid itself.

Active and Reactive Power Management: Modern converters are increasingly required to manage both active and reactive power.

- Active Power Adjustment: Active power is the actual usable power that performs work. Converters adjust active power output to match the load demand without wasting energy. This involves increasing or decreasing power output in response to the grid's immediate energy needs, thereby improving the overall efficiency of power generation and distribution.

- Reactive Power Control: Reactive power is required to maintain the voltage levels necessary for electrical systems to function properly. It does not perform any actual work but is essential for maintaining the health of the electrical grid. Converters that can control reactive power contribute to voltage regulation and stability, which is increasingly important in grids with fluctuating supply due to the intermittent nature of some renewable energy sources.

By providing these grid support functions, inverters play a critical role in the integration and efficiency of solar and battery energy systems, ensuring that they not only contribute to but also enhance the reliability and stability of the electrical grid. This dual capability of adjusting active and reactive power allows solar power systems to be more than mere energy producers; they become integral components of smart grid solutions, contributing to a more flexible and responsive power infrastructure.

Table 3-7 provides the most important standards that cover many grid support functions for a grid connected inverter. All or a subset of certification to these standards is required for a PV inverter to be installed in certain markets globally. For the U.S. market, the UL 1741 Standard is the “Standard for Safety - Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources”. It is based on the IEEE 1547 “Standard for Interconnecting Distributed Resources with Electric Power Systems”. A UL 1741 listing is generally required for all PV, BESS, and hybrid converters that connect to the utility grid in North America and are employed in utility scale systems. Certification to this standard involves a series of design inspections and tests. Especially challenging are the Anti-Islanding, grid protection, surge, and EMI testing requirements. Some non-UL listed converters are deployed in North America that implement utility interactive features that are not compatible with UL 1741. These are generally used in “behind the fence” applications where electric utilities are the customer for the power plant or receive local permitting approval on a case-by-case basis. International standards such as IEC 62786 and IEC 62116 provide overarching guidelines for grid stabilization functions, including voltage and frequency regulation, reactive power support, fault ride-through, and anti-islanding protocols.

Outside North America, standards governing advanced grid-support functions for distributed energy resources (DERs), including PV inverters and battery energy storage systems (BESS), emphasize ensuring dynamic compatibility with modern grids. These standards require functionalities such as reactive power support, frequency response, and fault ride-through capabilities to stabilize grid operations. In the European Union, EN 50549 mandates reactive power control, voltage regulation, and frequency-dependent active power modulation for low- and medium-voltage grid connections. Similarly, VDE-AR-N 4110 and 4105 in Germany require DERs to support Q(U) characteristic control for voltage stability, fault ride-through, and frequency droop control to mimic grid inertia. In Italy, CEI 0-16 includes extensive medium-voltage requirements, such as voltage and frequency regulation during dynamic grid events. In Australia and New Zealand, AS/NZS 4777.2 specifies advanced grid-support functions such as Volt-VAR and Volt-Watt responses for voltage stability, frequency response capabilities to manage frequency deviations, and active power ramping during disturbances. In Asia, GB/T 19964 in China mandates dynamic reactive power control, Q(V) characteristics, and active power curtailment during over-frequency events, along with voltage and frequency ride-through capabilities. India’s CEA Technical Standards emphasize frequency response for demand management, reactive power injection for voltage stabilization, and seamless transitions between grid-tied and islanded operations.

These standards ensure DERs actively contribute to grid stability and are critical for regions with high renewable energy penetration and evolving grid infrastructure needs. Compliance with these requirements supports the reliable and efficient integration of DERs into modern power systems globally.

Table 3-7 Standards covering grid-support functionalities

Standard	Title
UL 1741	Standard for Safety Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 1741 SA and SB	Supplement specifications for Grid Support Utility Interactive Inverters
IEEE 1547-2018	Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE 1547.1-2020	Standard for conformance test procedures for equipment interconnecting distributed resources with Electric Power Systems
IEC 62477	Safety requirements for power electronic converter systems and equipment
CSA 22.2 No. 107.1-3	Safety Requirements for General Use Power Supplies (Canada)

SolarEdge TerraMax PV inverters are equipped with grid support functions designed to meet interconnection standards for utility and distributed generation systems. These functions enable the inverter to remain operational and support grid stability during voltage and frequency disturbances. The key features include voltage and frequency ride-through (LFRT, HFRT, LVRT, HVRT), active and reactive power control, and response mechanisms to grid conditions such as voltage or frequency deviations. According to the product datasheets, the inverters support fixed power factor settings, configurable reactive power output (fixed Q), and control schemes such as Volt-VAR, Frequency-Watt, and Cos(ϕ)/Watt. These functions allow the inverter to adjust its output in accordance with local grid codes. Ramp rate control is also included to manage the rate at which power output changes, reducing abrupt fluctuations in power feed-in.

Test results presented in the EN 50549-2 type certification report confirm these functionalities. For reactive power control (Q control), the inverter was tested at 50% of nominal power with both under-excited and over-excited setpoints. The reactive power deviation was measured within ±0.7% of rated apparent power, which meets the standard's allowable tolerance of ±2% of Smax. In dynamic testing, the inverter was subjected to step changes in reactive power demand. With a configured settling time of 3 seconds, the inverter responded and stabilized within ±5% of the setpoint, demonstrating compliance with required dynamic response characteristics. Voltage-dependent reactive power behavior was evaluated using the Q(U) function. The inverter followed the specified voltage-reactive power curve accurately, without overshoot or instability. The system respected the lock-in and lock-out voltage thresholds and enforced minimum active power factor limits as configured. For active power control, including frequency-watt response (P(f)), the inverter adjusted its output in accordance with frequency variations. Test scenarios involving step changes in frequency showed that the inverter's active power output remained within ±10% of rated power, as required by the standard. The deadband and response delay parameters were verified to behave consistently with configured values.

Overall, the combined data from the product datasheets and the EN 50549-2 test report demonstrate that SolarEdge TerraMax inverters are capable of performing advanced grid support functions, including reactive power regulation, frequency response, and dynamic ride-through capabilities, all within the tolerance and performance criteria specified by applicable grid codes.

3.7.5 Grid forming capability

The SolarEdge TerraMax PV inverters are designed to operate in grid-tied mode. They synchronize with grid voltage and frequency and operate in grid-following mode. They do not support grid forming capabilities.

3.8 Product efficiency

3.8.1 Power optimizer efficiency

Efficiency is a key metric of the SolarEdge Power Optimizer performance. According to the manufacturer datasheets, both the H1300 and H1500 power optimizers have a maximum efficiency of 99.5% and a weighted efficiency of 98.8%. DNV did not review any third-party performance test reports or laboratory measurements of efficiency.

3.8.2 TerraMax PV inverter efficiency

Operating efficiency is indeed a crucial metric for both PV and BESS converters. These converters must efficiently convert input power from solar panels or batteries into usable output power for various applications. Efficiency is not a fixed value but varies depending on the load level and input voltage. Therefore, it's important to assess efficiency at different operational points to understand how effectively the converter performs under various conditions. High efficiency ensures that energy is not wasted during the conversion process, maximizing the system's overall performance, and minimizing operating costs.

The efficiency of the SolarEdge SE330K inverter has been evaluated through both datasheet specifications and independent third-party testing in accordance with IEC 61683. The test report (No. 230715-1-TR, issued by CERE) confirms the inverter's performance under standardized operating conditions and a range of load levels.

According to the SolarEdge datasheet, the SE330K inverter is rated with:

- Maximum efficiency: 99.2%
- Weighted efficiency (European): 98.8%

These values are representative of ideal operating conditions and provide a benchmark for expected inverter performance. The IEC 61683 test report presents measured efficiency data at several power levels (10%, 25%, 50%, 75%, and 100% of rated power), across three input voltage conditions: nominal (1250 V), minimum (1200 V), and high (1350 V). Key findings from the measured data include:

- At 100% load, measured efficiency ranged from 98.65% to 98.96%, depending on the input voltage.
- The peak efficiency observed was 99.31% at 50% rated load, which is consistent with expected behavior for modern PV inverters, where efficiency is typically highest near mid-load conditions.
- The energy efficiency values (which integrate power over time) showed slightly lower results, ranging from 97.42% to 99.00%, depending on voltage and load conditions.

The inverter was unable to be tested at 120% load, which was waived due to design limitations noted in the report.

In terms of no-load and standby losses:

- No-load power consumption was measured at 90.45 W
- Standby power consumption was measured at 91.37 W

The test results confirm that the measured maximum efficiency of 99.31% falls within the expected margin relative to the datasheet value of 99.2%. Slight differences in efficiency at specific load points and input voltages are within the measurement uncertainty and standard tolerances.

The CEC weighted efficiency of the SolarEdge TerraMax inverter series was independently tested according to the California Energy Commission (CEC) Performance Test Protocol (March 1, 2005), as documented in report No. 104384166CRT-002 issued by Intertek Testing Services NA, Inc. The report provides measured efficiency data for the inverter models targeted towards NAM - SE330KUS (690 Vac output), SE285KUS (600 Vac output), and SE250KUS (600 Vac output). The efficiency curves as measured by Intertek are presented in Figure 3-11 through Figure 3-13. The CEC weighted efficiency for all the models is measured to be greater than 98.5% (the average CEC efficiency of similar inverters in market [1]). This is leading compared to similar inverters in market.

Manufacturer Name: SolarEdge Technologies Ltd.
Model Number: SE330KUS
Output Voltage (Vac) 400

Maximum Continuous Output Power: 329.741 kW   Night Tare Loss: 20.9 W

Vmin: 1200 Vdc   Vnom: 1260 Vdc   Vmax: 1400 Vdc

		Power Level (%; kW)						
		10%	20%	30%	50%	75%	100%	
Input Voltage (Vdc)		32.974	65.948	98.922	######	247.306	329.741	Wtd
Vmin	1200	97.96	98.85	99.05	99.16	99.03	98.87	99.00
Vnom	1260	97.69	98.74	98.97	99.09	99.00	98.82	98.94
Vmax	1400	97.14	98.51	98.81	98.91	98.94	98.78	98.82

CEC Efficiency = 98.9%

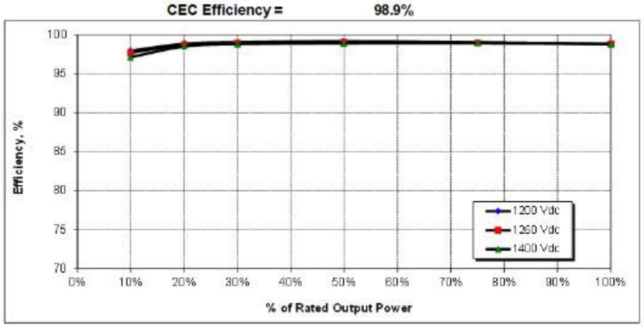


Figure 3-11 Measured efficiency curves for SE330KUS inverter model as measured by Intertek

Manufacturer Name: SolarEdge Technologies Ltd.
Model Number: SE285KUS
Output Voltage (Vac) 346.4

Maximum Continuous Output Power: 284.159 kW   Night Tare Loss: 21.6 W

Vmin: 1090 Vdc   Vnom: 1250 Vdc   Vmax: 1320 Vdc

		Power Level (%; kW)						
		10%	20%	30%	50%	75%	100%	
Input Voltage (Vdc)		28.416	56.832	85.248	######	213.120	284.159	Wtd
Vmin	1090	98.10	98.88	99.01	98.97	98.86	98.65	98.86
Vnom	1250	97.47	98.60	98.84	98.88	98.81	98.60	98.75
Vmax	1320	97.22	98.49	98.77	98.85	98.78	98.60	98.71

CEC Efficiency = 98.8%

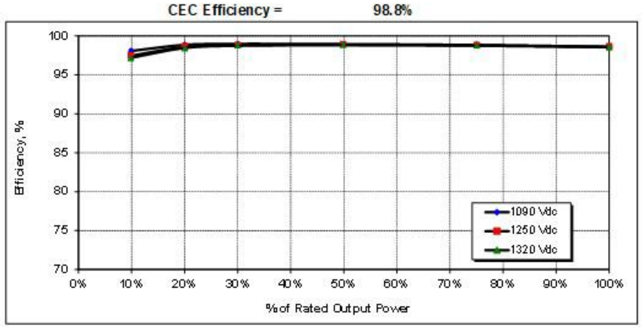


Figure 3-12 Measured efficiency curves for SE285KUS inverter model as measured by Intertek

Manufacturer Name: SolarEdge Technologies Ltd.
Model Number: SE250KUS
Output Voltage (Vac) 346.5

Maximum Continuous Output Power: 249.907 kW   Night Tare Loss: 21.61 W

Vmin: 1090 Vdc   Vnom: 1250 Vdc   Vmax: 1320 Vdc

		Power Level (%; kW)						
		10%	20%	30%	50%	75%	100%	
Input Voltage (Vdc)		24.991	49.981	74.972	######	187.430	249.907	Wtd
Vmin	1090	97.90	98.79	98.97	98.99	98.91	98.76	98.88
Vnom	1250	97.16	98.48	98.77	98.89	98.84	98.70	98.75
Vmax	1320	96.87	98.35	98.69	98.84	98.81	98.68	98.70

CEC Efficiency = 98.8%

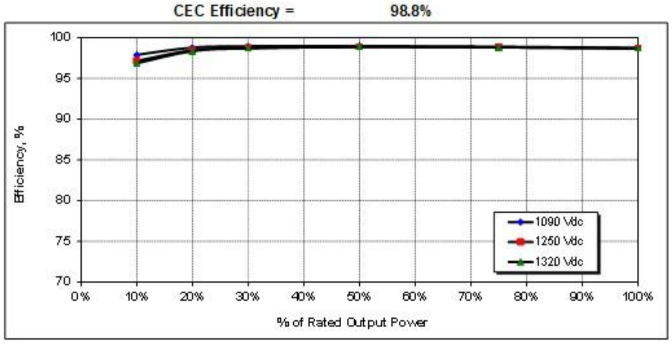


Figure 3-13 Measured efficiency curves for SE250KUS inverter model as measured by Intertek

The efficiency data provided in the datasheet is consistent with the independent laboratory measurements conducted under IEC 61683 and CEC performance test protocol. The efficiency of the SolarEdge TerraMax series PV inverters is leading when compared to other inverters with similar power ratings currently available on the market.

3.9 Controls, communications, and cybersecurity

3.9.1 MPPT algorithm

The module level MPPT algorithm implemented by SolarEdge in the optimizer has been described to DNV as a Perturb and Observe (P&O) method with added features to overcome the disadvantages and achieve better power optimization. The typical P&O algorithm is used in many PV applications for MPPT functionality and is most commonly included in the inverter instead of at the module level. SolarEdge indicated that an MPPT update period in the millisecond range is being used, which is relatively fast. This can provide for good dynamic performance to changing irradiance conditions. DNV understands that SolarEdge also employs additional methods to confirm that the operating point is the global maximum power point. Figure 3-14 provides an example of where a P&O algorithm without additional methods for finding the maximum power point can readily get stuck on the wrong point.

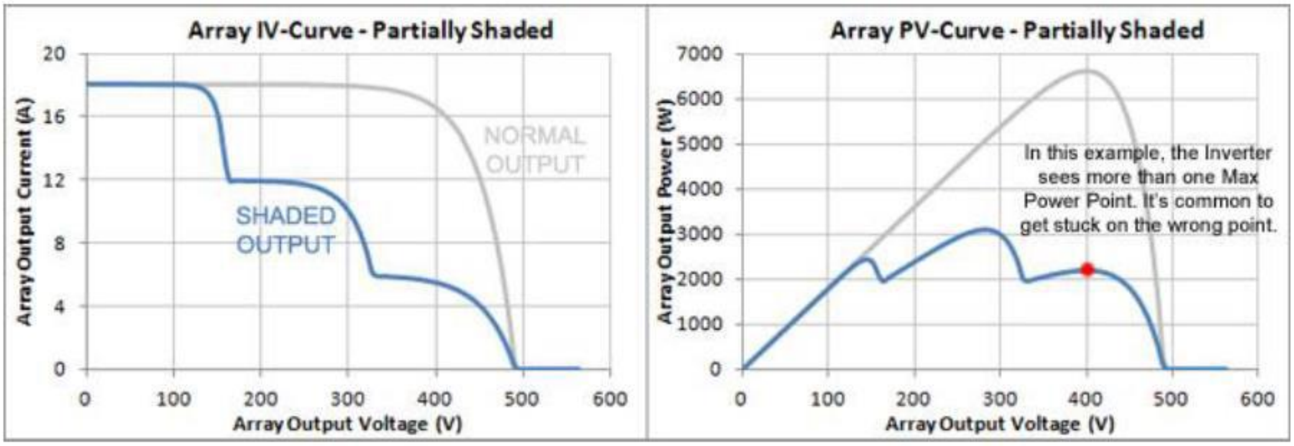


Figure 3-14 Example of partially shaded panels

For a previous DNV report, SolarEdge had provided four reports with supporting Excel spreadsheet data as evidence of MPPT validation testing. Additionally, DNV observed the MPPT operating properly during the previous site visits that are described in Section 9.1 of report '10361427-HOU-R-01', which can be directly requested from SolarEdge. DNV views positively the MPPT approach taken by SolarEdge. Also, as part of a previous, SolarEdge had provided four test reports with associated data for the optimizer MPPT test results that including shading tests. The reports reviewed represent ongoing efforts by SolarEdge to validate the MPPT functionality.

3.9.2 Controls and communications

The SolarEdge TerraMax PV inverters include an integrated communication and control system designed to support both internal coordination and external system interfacing. The architecture of the implemented communications is shown in Figure 3-15. The control functions manage inverter operation, fault detection, thermal regulation, and output power regulation. These functions are supported by multiple communication interfaces that facilitate both local and remote system monitoring, inverter coordination, and compliance with data acquisition standards.

The inverter's control system manages internal functional blocks such as MPPT logic, thermal derating, grid support functions (e.g., ride-through, reactive power control), and inverter synchronization. It includes monitoring of electrical parameters and environmental sensors and interfaces with external systems for real-time data reporting and configuration.

Configuration and commissioning are handled via the SetApp mobile application, which connects locally to the inverter via a built-in Wi-Fi hotspot. Through this interface, parameters such as IP settings, communication mode (leader/follower), power control profiles, and grid code compliance settings are defined.

The TerraMax PV inverters support several physical communication interfaces:

- Ethernet (RJ45): Built-in port used for wired LAN connection to the SolarEdge monitoring server or third-party data loggers. Inverters are preconfigured to obtain network settings via DHCP, but static IP addressing is also supported. The maximum distance for direct Ethernet cable connection is 100 meters.
- CAN Bus: Used for internal inverter networking in multi-inverter installations. The CAN bus supports a leader/follower architecture where only the leader connects to external networks. Up to 12 follower inverters can be managed by one leader. The CAN network can span up to 750 meters.

- RS485-1: A terminal block supports RS485 communication for connecting to external energy meters or third-party monitoring systems using the SunSpec protocol.
- Wi-Fi (Optional): Wireless connectivity via a SolarEdge plug-in module. This enables connection to the monitoring platform through a local Wi-Fi network. Only the leader inverter in a CAN-based system needs to be equipped with Wi-Fi.
- Cellular (Optional): A plug-in LTE modem allows remote communication without wired or Wi-Fi infrastructure. In multi-inverter systems, only the leader inverter requires a cellular connection. Cellular connectivity supports 5-minute data sampling intervals.

Each communication option is supported by specific setup procedures available through the SetApp interface. Communication status is verified either visually via LED indicators or through software menus confirming connection status with the SolarEdge server.

In addition to SolarEdge's proprietary monitoring platform, the inverters support integration with third-party systems:

- SunSpec Modbus over RS485 or TCP/IP can be used to interface with external loggers or monitoring systems.
- Non-SolarEdge loggers can access inverter data either via RS485 or directly over Ethernet using Modbus TCP.

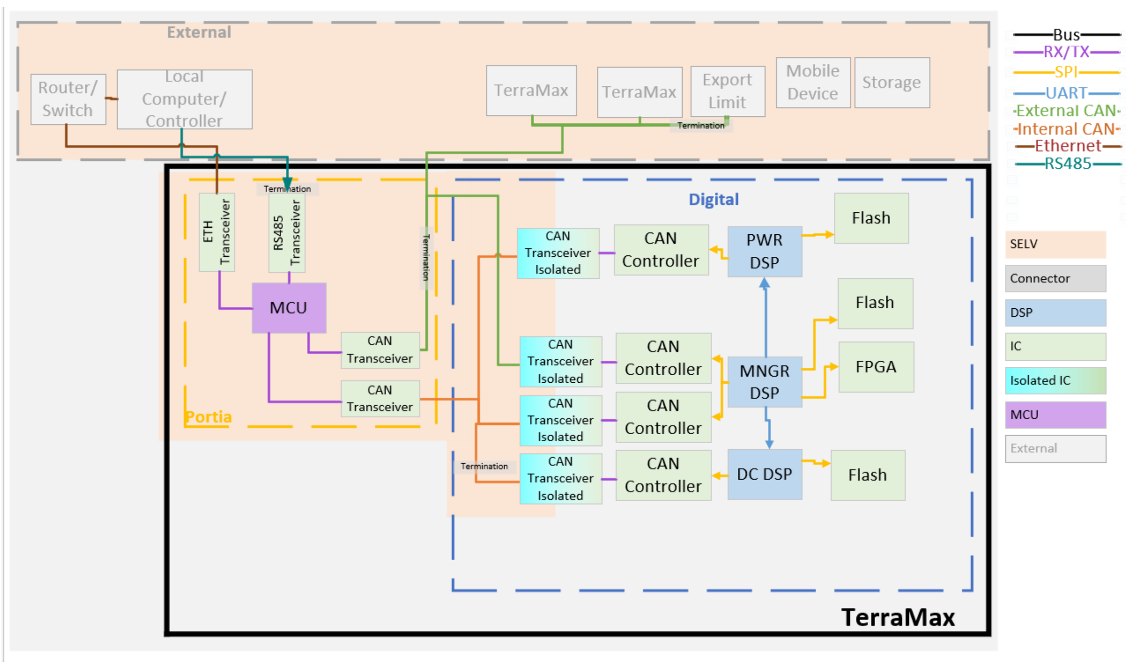


Figure 3-15 Communications architecture implemented in TerraMax series PV inverters

3.9.3 Cybersecurity

DNV reviewed SolarEdge's approach to cybersecurity considerations for the TerraMax PV inverters. The SolarEdge TerraMax inverter series incorporates a multi-layered cybersecurity architecture designed to protect against unauthorized access, data manipulation, and system-level cyber threats. The implementation follows a four-pillar approach covering device security, data security, network safeguards, and visibility and control.

Device Security: At the hardware and firmware level, the inverters include mechanisms to prevent tampering and unauthorized use. Each device is shipped with a unique, randomly generated Wi-Fi access password, eliminating risks associated with default credentials. Product activation requires three factors: physical access, login via an authorized SolarEdge installer account, and the unique device password. Remote access is only possible through authenticated SolarEdge channels, with strict role-based access control (RBAC) and session monitoring. Physical access protections include closed debug ports, tamper-resistant enclosures, and secure local access procedures. Additionally, local Wi-Fi access is time-limited and requires physical interaction with the unit to activate. Software and firmware integrity are protected through cryptographically authenticated updates, with whitelisting and validation of executable files. Firmware downgrades are not permitted, and remote updates are only initiated by the device, ensuring controlled version management.

Coming enhancements in 2025 include:

- Secure Boot, preventing unauthorized software from running at startup.
- Multi-Factor Authentication (MFA) and Federated Single Sign-On (SSO) for installer accounts.

Data Security: Data exchanged between the inverter and the SolarEdge backend is encrypted using TLS 1.2+ (with migration to TLS 1.3) and strong cipher suites. Stored data on devices includes only operational data (e.g., voltage, current, temperature); no personal or financial data is stored locally. Sensitive elements, such as cryptographic keys and configuration data, are stored in a secure hardware-backed memory environment, including ARM TrustZone-based protection (planned for future releases). In offline mode, core system functions like PV generation and storage operation remain unaffected. Monitoring and remote support resume once internet connectivity is restored.

Network Safeguards: SolarEdge inverters initiate all outbound communications, following an asymmetric communication model that limits exposure to unsolicited network traffic. Devices do not open inbound ports, reducing the risk of attack via common internet scanning techniques. Multiple communication modes are supported: Wired Ethernet, Wi-Fi (secured with WPA2-PSK and AES-128), and optional cellular modem (for air-gapped networks).

Gateways in multi-inverter configurations act as central communication hubs, minimizing attack surfaces. All internal device-to-device communication undergoes strict input validation to ensure protocol compliance and block malformed or malicious data.

Visibility and Control: The inverters support detailed logging and monitoring, with events such as login attempts, firmware integrity checks, and abnormal operating conditions recorded and stored for 6–24 months. These logs are made available to SolarEdge’s Security Operations Center (SOC) for centralized monitoring and threat detection. Alerts can also be integrated into customer-side SIEM systems upon request. Customers may enforce "safe mode", where devices block all incoming commands unless physical access is granted for remote support. Firewall rules based on FQDN whitelisting are used to manage allowed cloud communications, further reducing the system’s vulnerability to unauthorized access.

Compliance and Standards: SolarEdge cybersecurity practices align with several international standards and frameworks, including:

- ISO/IEC 27001:2022
- ETSI EN 303 645 (IoT security)
- IEC 62443-4-1 (secure software development lifecycle)
- ENISA guidelines
- UL 2941

- NIST IR 8498 – Cybersecurity for Smart Inverters
- European RED Article 3.3 and NIS2 Directive
- UK-PSTI (Product Security and Telecommunications Infrastructure)

This cybersecurity implementation reflects a comprehensive and regulated approach tailored for distributed energy resource (DER) systems operating in networked environments, with a focus on operational continuity, data integrity, and controlled access. DNV considers these cybersecurity capabilities positively.

4 QUALITY AND RELIABILITY

Reliability and quality are central considerations throughout the product development and manufacturing processes, especially in the case of power converters like inverters. Here's how these aspects are addressed at various stages:

Design Phase:

- Design for Reliability: The design prioritizes inherent reliability by choosing durable components, incorporating redundancy in critical systems, and planning for fault tolerance.
- Testing and Simulation: Rigorous testing and simulation are performed during design to identify potential weaknesses and ensure the converter's performance under various conditions.
- Failure Mode Analysis: Engineers analyze potential failure scenarios and develop strategies to prevent or mitigate them.

Testing Phase:

- Quality Assurance Testing: Comprehensive testing verifies that each converter unit meets design specifications and quality standards, including performance, stress, and reliability testing.
- Environmental Testing: Converters undergo environmental testing to assess their performance in extreme conditions such as temperature variations, humidity, and vibration.
- Life Cycle Testing: Accelerated life cycle testing simulates years of operation in a shorter time frame, predicting long-term reliability.

Manufacturing Phase:

- Process Control: Strict process control ensures consistency and quality in production by monitoring tolerances, manufacturing processes, and standardized procedures.
- Quality Management Systems: Many manufacturers adhere to quality management standards like ISO 9001 to maintain high manufacturing standards.
- Material Control: Stringent material control procedures ensure that components meet specifications and are defect-free.

Field Performance and Feedback:

- Field Monitoring: Remote monitoring of converter performance in the field identifies anomalies or issues.
- Customer Feedback: Customer feedback is vital for identifying improvements or issues not found during testing, informing future design iterations.

Continuous Improvement:

- Corrective Action: Prompt actions are taken to address issues identified in the field or during testing. This may involve design changes, process improvements, or component updates to enhance reliability and performance.
- Iterative Design: An iterative design process ensures that each generation of converters benefits from lessons learned from previous models, leading to ongoing enhancements in reliability and quality.

In summary, reliability and quality are integrated into every phase of converter development and manufacturing. This comprehensive approach ensures that converters not only meet customer expectations but also evolve to deliver higher levels of performance, reliability, and dependability over time.

4.1 Design for reliability

Designing for reliability involves several crucial elements, including:

- Component Selection and Derating: Carefully choosing components based on their quality and suitability for the intended application. Implementing derating, which involves operating components below their maximum specified limits to enhance reliability.
- Analytical Reliability Calculations: Employing analytical methods to calculate the Mean Time Between Failures (MTBF) or other reliability metrics. These calculations help estimate the expected time between failures for components or the entire system.
- Failure Mode Analyses (FMEA): Conducting systematic analyses to identify potential failure modes, their root causes, and their potential impacts on the system. FMEA helps in developing strategies to mitigate or prevent failures.
- Engineering Processes: Implementing structured engineering processes during the design phase to ensure that design guidelines and reliability criteria are consistently met. These processes serve as control gates to validate and verify the design's reliability.

These elements collectively contribute to a robust design for reliability, ensuring that electronic products are durable, perform consistently, and have a longer service life.

4.1.1 Component selection and derating

To achieve a high level of product reliability, it is crucial to select quality components and design for operation within stress levels that ensure consistent performance throughout the product's service life. This typically involves adhering to in-house design guidelines that dictate acceptable stress levels for individual components. These guidelines often incorporate derating factors, which involve operating components at levels below their maximum specified limits. This practice applies to various factors, including:

- Junction Temperature of Semiconductor Devices: Components like semiconductor devices (e.g., transistors, diodes) have specified maximum junction temperatures. Derating involves operating these devices at temperatures lower than their maximum limits to prevent overheating and premature failure.
- Ripple Current for Capacitors: Capacitors are subjected to ripple currents, and derating involves using capacitors with higher rated current capabilities than what the application requires. This ensures that capacitors do not experience excessive stress from current fluctuations.
- Applied Voltage: Derating with respect to voltage means operating components, such as resistors, at voltages lower than their maximum ratings to prevent voltage-induced failures or breakdowns.
- Ambient Temperature: Design guidelines may specify operating components at lower temperatures than the maximum ambient temperature allowed. This helps maintain component reliability in varying environmental conditions.

By following these guidelines and implementing derating practices, manufacturers aim to improve the overall reliability and longevity of their products. This approach helps ensure that components do not operate at stress levels that could lead to premature failure, ultimately enhancing the product's reliability and performance over its service life.

DNV reviewed design margin practice followed by SolarEdge. SolarEdge applies a formal and systematic approach to component derating in its inverter and power electronics. The company’s derating practices are governed by internal engineering guidelines and are aligned with international standards, notably ECSS-Q-ST-30-11C Rev.2. SolarEdge's internal derating guidelines require:

- 20% voltage and current margins relative to absolute maximum ratings (AMR) for all components.
- Thermal and electrical stress calculations performed during the design phase, with continuous validation via testing and simulations.
- Component selection and layout considerations designed to ensure safe operation under worst-case steady-state and transient conditions.

Measured values from prototype validation include:

- SiC MOSFETs (e.g., M1/M2): Operated at a maximum junction temperature of ~115°C against a component-rated limit of 150°C. Power loss and thermal resistance were used to calculate thermal rise, confirming acceptable margins.
- IGBTs (e.g., Q1, Q3): Similarly operated with a junction temperature capped at 108–115°C, well below the component's rated limit of 150°C.
- DC-Link Electrolytic Capacitors: Core temperature during operation was measured at 75°C against a maximum allowable rating of 105°C, showing a 30°C operating margin.

These limits are verified through in-situ testing, with thermal measurements derived using internal NTC sensors and test methodologies aligned with semiconductor manufacturer recommendations.

Overall, the general derating guidelines practiced by SolarEdge defines the following margins for major component categories:

IGBTs / FETs / SiC Devices

- Voltage, current, and gate drive limits set to 80% of the rated value
- Junction temperature capped at 115°C or Tjmax – 35°C, whichever is lower
- Allowance for 85% voltage for very short (<50ns) transients

Capacitors (Electrolytic)

- Ripple current limited to 80% of the datasheet maximum
- Surge current limited to 75%
- Internal temperature rise limited to 10°C above ambient

Inductors and Transformers

- Maximum voltage set at 50% of insulation test rating
- Hot spot temperature must be at least 25°C below the material's rated limit

Resistors

- Operating voltage limited to 80%
- Power dissipation capped at 70% of the rated value at case temperature

- Package temperature must be 25°C below the manufacturer's maximum

Connectors and Fuses

- Current limited to 80%
- Temperature derated by 20°C from rated maximum
- Fuse current rating applied at 50% load margin

SolarEdge specifies that derating guidelines apply to all components unless their usage is limited to less than 720 hours over the product's lifetime, and only if operating within rated limits. SolarEdge enforces these derating requirements across its inverter design cycles, ensuring that margins are considered during component selection, thermal design, and layout validation phases. This practice supports compliance with grid reliability expectations and long-term durability of its power conversion systems.

DNV views this practice of component derating and evaluation to assess the actual margins, followed by SolarEdge, positively.

4.1.2 Mean time between failure (MTBF)

An MTBF estimation combines the expected failure rates of each component in a system and sums the results in order to estimate the MTBF of a product/system in a theoretical, desktop exercise. This helps with product lifetime estimates and improving product reliability during the design phase. MTBF data is then later confirmed with system testing and field data.

DNV underscores the significance of employing a robust analytical approach to assess the reliability of power converters during the development phase. DNV emphasizes the importance of consistently using this analytical reliability approach and highlights that the Mean Time Between Failures (MTBF) methodology plays a crucial role in this assessment. The primary advantage of utilizing MTBF is its capability to pinpoint specific components that have the most adverse impact on the overall reliability of the product. This approach helps identify critical areas for improvement and enhances the overall reliability of converters.

The MTBF for the SolarEdge TerraMax inverter was evaluated using the Telcordia SR-332 Issue 4 standard. The analysis was based on an operating profile of 8 hours per day, 5 days per week (20% duty cycle) at an ambient temperature of 40°C. Under these conditions, the inverter was calculated to have an MTBF of approximately 420,016 hours, equivalent to 47.97 years. The Mean Time To Failure (MTTF) was reported as 467,692 hours (or 53.38 years), with an estimated failure rate of 2,381 FIT (Failures in Time, or failures per billion hours). These values reflect statistical reliability based on component-level failure modeling and environmental assumptions.

For the SolarEdge Gen4 H1300 power optimizer (model AP1266A-AO-07-SV), MTBF was calculated using Telcordia SR-332 Issue 3 guidelines. At a reference temperature of 36°C in a ground fixed environment, the optimizer demonstrated an MTBF of approximately 9,596,122 hours. The failure rate at this condition was estimated at 104.2 FIT. Temperature sensitivity was also evaluated, showing higher MTBF values at lower ambient temperatures (e.g., over 13 million hours at 25°C) and lower MTBF at higher temperatures (e.g., 1.57 million hours at 85°C). Primary contributors to failure rates included specific components such as TVS diodes, crystal oscillators, MOSFETs, and ICs, though overall reliability remained high across the evaluated conditions.

DNV clarifies that the MTBF score is not intended to predict the entire lifespan of a converter. Instead, its primary purpose is to provide a quantifiable measure of component reliability, particularly for design and development purposes. In other words, MTBF is used as a tool to assess and improve the reliability of specific components within the converter, rather than to predict the entire life expectancy of the converter as a whole.

4.1.3 Failure mode effects analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a systematic technique that was originally developed by reliability engineers in the 1950s to analyze and understand potential failures, particularly in military systems. FMEA serves as an initial step in conducting a comprehensive study of a system's reliability. The process involves a thorough examination of various components, assemblies, and subsystems to uncover potential failure modes, understand the root causes behind these failures, and assess the consequences they might have on the overall system. For each individual component, FMEA worksheets are used to document the identified failure modes and the subsequent impacts they could have on the system. There are various versions of these worksheets tailored to specific applications. FMEA aims to recognize potential failure modes either by drawing from past experiences with similar products and processes or by applying fundamental principles of failure physics. FMEA finds utility in multiple industries and stages of a product's lifecycle, making it a valuable tool for identifying and mitigating potential reliability issues.

DNV reviewed the FMEA analysis from SolarEdge for the TerraMax PV inverters. The FMEA report for the SolarEdge TerramMax system identifies potential failure modes across electrical, mechanical, and system-level components. Each failure mode is evaluated using a Risk Priority Number (RPN), which is the product of severity (S), occurrence (O), and detection (D). Items with high RPNs are targeted for corrective action or design changes. The assessment includes input from engineering, reliability, product management, and quality assurance teams.

Electrical and Component-Level Failures: Several high-risk issues were identified in the electrical system, such as IGBT and SiC overheating, capacitor degradation, and relay failures. Notably, the highest initial RPN (384) was associated with SiC overvoltage and capacitor bank imbalances, both of which carry safety implications. Mitigations include firmware-based shutoff mechanisms, voltage balancing circuits, and temperature monitoring using thermocouples. Other issues, like RCD failures and overcurrent conditions, were addressed through built-in self-tests and firmware protection routines.

Mechanical Design and Installation Risks: Mechanical issues included component damage from improper transport or installation, direct sun exposure, and cable routing obstructing ventilation. Failures in mounting infrastructure and improper sealing of covers also appeared with moderate to high initial RPNs. Design changes, such as using supporting brackets, recommending shaded installation, and improving torque specifications, were implemented to reduce risks.

System Assembly and Serviceability: Assembly-related concerns involved poor thermal connections, relay busbar connection issues, and foreign object damage (FOD) during both manufacturing and field maintenance. These were addressed through assembly procedure updates, redesign of connectors (e.g., changing cables to busbars), and use of protective hardware. Serviceability issues such as board replacement limitations and misaligned covers were noted, with future redesigns recommended for ease of maintenance.

Handling and Operational Hazards: Field-related hazards included unsafe PV voltages during installation, reversed DC polarity, and insufficient terminal tightening. These risks carried RPNs up to 576 in their initial assessment, particularly for open-circuit PV voltage exposure. Corrective actions included “SafeDC” voltage logic, thermal sensor integration, torque-limited tools, and installer training.

The FMEA identifies a range of potential reliability and safety risks in the TerraMax inverter system. Many of the initial high-RPN items (≥160) were mitigated by design changes, additional protective circuitry, improved installation guidance, or firmware updates. The FMEA process highlights a proactive reliability strategy, with traceable mitigations and updates targeted at reducing both component-level failures and system-level hazards across the inverter lifecycle.

DNV has a positive view of the reliability design practices implemented by SolarEdge.

4.2 Product testing

Product testing is a comprehensive process that encompasses various stages, from initial functional verification to accelerated life testing. Designers employ diverse test methodologies to ensure that power converters perform reliably throughout their expected lifespan, aligning with customer expectations. This rigorous testing process is crucial for validating converter performance and reliability.

4.2.1 Design verification testing (DVT)

Before mass production, there is one stage of prototyping, continuous design and process improvements during this process. Verification tests or analysis performed during the design stage include thermal/electrical/mechanical design and component sizing/selection, and multiple stages of Design Verification testing (DVT).

The design verification process for SolarEdge TerraMax inverters includes extensive testing to validate thermal behavior, component protection strategies, and operational derating across various environmental conditions. Three core documents—covering thermal management, derating characteristics, and component-specific behavior—outline the methodology and verification steps taken.

Thermal Derating Verification: The TerraMax inverters are designed to operate at full power up to an ambient temperature of 45°C (113°F). Above this threshold, the system initiates power derating, reducing output current proportionally to protect internal components from thermal stress. The derating profile is implemented through real-time monitoring of key component temperatures using NTC (Negative Temperature Coefficient) sensors grouped by function (e.g., SiC switches, IGBTs, capacitors, ac/dc terminals, and ambient). Each group has predefined derating start and stop thresholds—for example, IGBT derating begins at 96°C and completes by 100°C; SiC devices derate between 91–95°C.

A centralized algorithm reads the maximum temperature in each sensor group, calculates the individual derating ratios, and selects the most limiting ratio to determine the new current reference for the power controller. If safe operating conditions cannot be maintained through derating, the inverter enters standby mode until temperatures fall below thresholds.

Fan Control and Terminal Temperature Monitoring: To support thermal regulation, the inverter uses a controlled fan system that adjusts speed based on internal temperature thresholds. Fans are managed by the inverter's internal controller (MNGR), and diagnostics such as RPM readings and fault conditions are monitored. Fan status is logged locally and communicated to SolarEdge's cloud system for fault reporting.

Additionally, terminal temperature measurement is used to detect unsafe ac and dc cable connections. Temperature sensors near the DC+/- and L1/L2/L3 terminals monitor for abnormal heat rise, which may indicate loose or high-resistance connections. If terminal temperatures enter a "critical" range, the inverter is locked out and must be manually reset via a support-issued unlock command. This mechanism prevents unsafe operation due to poor installation or degradation at the connection points.

Derating Characteristics and Product-Specific Validation: The SolarEdge derating verification report specifies validated derating limits for each TerraMax model:

- TheTerramax series PV inverters operate at full rated output up to 45°C (113°F) ambient. Above this, output is progressively reduced in accordance with verified derating curves.

- These curves define current reduction versus ambient temperature and are used across system design and installation documentation.

The derating profiles have been validated using field measurements, thermal simulations, and hardware testing. Component temperatures under maximum load conditions are compared to manufacturer datasheet limits, with margins factored in for reliability.

Design verification testing for TerraMax inverters confirms that the units are capable of protecting themselves against over-temperature conditions through an integrated system of sensor-based derating, fan regulation, and terminal temperature detection. These features are validated through simulation, lab testing, and internal quality procedures.

4.2.2 Accelerated life testing (ALT)/Highly accelerated life testing (HALT)

Accelerated life testing (ALT) is a valuable process used to assess and estimate the operational lifespan of newly developed inverter products within a shorter timeframe. It subjects the product to conditions that exceed its normal operating limits, employing specific acceleration factors to induce product or component failures. Stress factors such as voltage, temperature, and vibration are typically applied during ALT. When combined with statistical modeling, ALT results can provide valuable insights into the expected service life of an inverter. DNV has observed a strong correlation between the industry's most reliable products and extensive ALT testing.

Highly Accelerated Life Testing (HALT) is another method for testing electronic equipment within a condensed timeframe to ensure reliable performance over its intended operational life. HALT involves subjecting the equipment to extreme conditions such as high and low temperatures, temperature cycling, and vibration. Any issues or weaknesses that arise during HALT are promptly addressed.

Highly Accelerated Life Testing (HALT): SolarEdge conducted HALT on the 330 kW TerraMax inverter to evaluate its mechanical integrity and operational limits under combined temperature and vibration stress. Two units underwent this testing at the Modiin HALT Laboratory. The inverter in HALT chamber is shown in Figure 4-1. The temperature tests ranged from +20°C to -80°C (cold start and operation) and up to +90°C on the high side. Both units remained operational across this full range. Derating was first observed at +90°C, indicating the onset of protective thermal control. Vibration tests at room temperature reached up to 20 gRMS without functional failure. The combined stress test subjected the inverters to rapid temperature cycling between -70°C and +90°C with simultaneous vibration (20 gRMS internal equivalent). Both units passed the test without performance degradation, physical damage, or failures during post-test inspections.

Figure 4-1 Picture of SE330K inverter in HALT chamber

Thermal Cycling Test (TC): Thermal cycling tests were conducted on three units of TerraMax SE330KUS to simulate long-term environmental stress using 23 days of exposure, equivalent to ten years of field life, according to a Coffin-Manson acceleration model. A picture of the experimental setup and its design is shown in Figure 4-2 and Figure 4-3, respectively. The inverters were exposed to internal temperature variations between -30°C and +80°C, with power output of 250 kW applied during heating cycles. No component damage, performance degradation, or failures were reported. Visual inspection and automated test equipment results showed no anomalies, and post-test efficiency variation remained below 0.1%, well within the ±3% acceptance threshold.

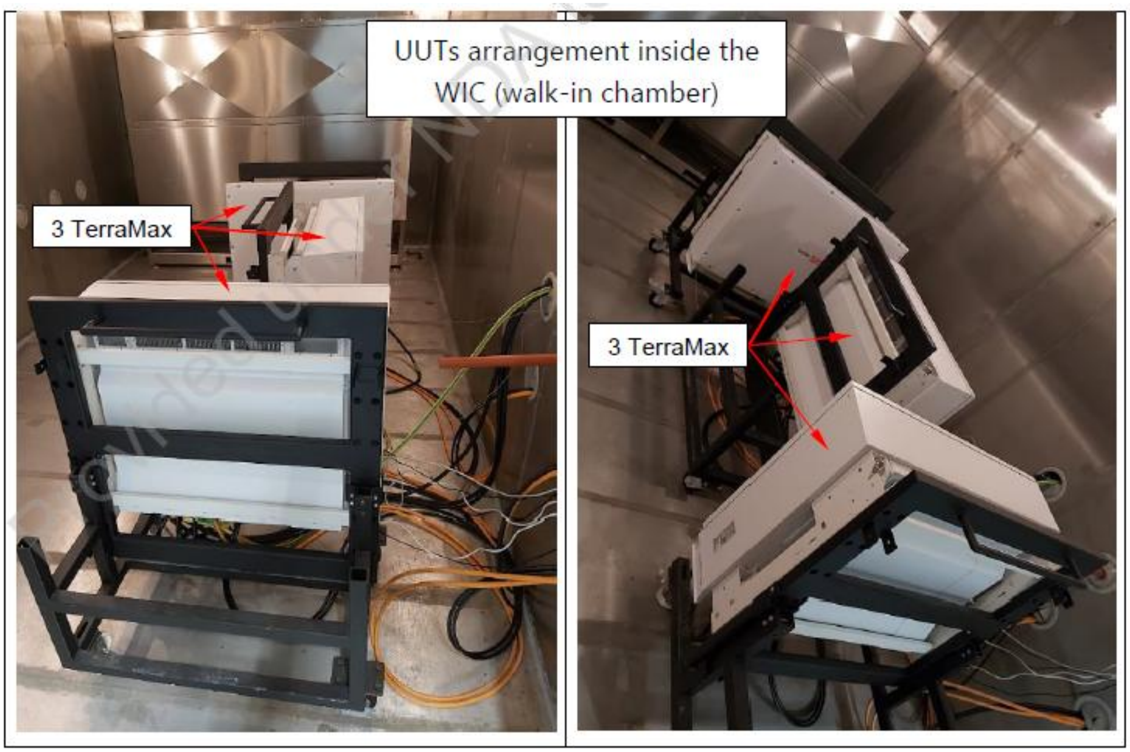


Figure 4-2 Setup used for thermal cycle and damp heat testing conducted on TerraMax PV inverters

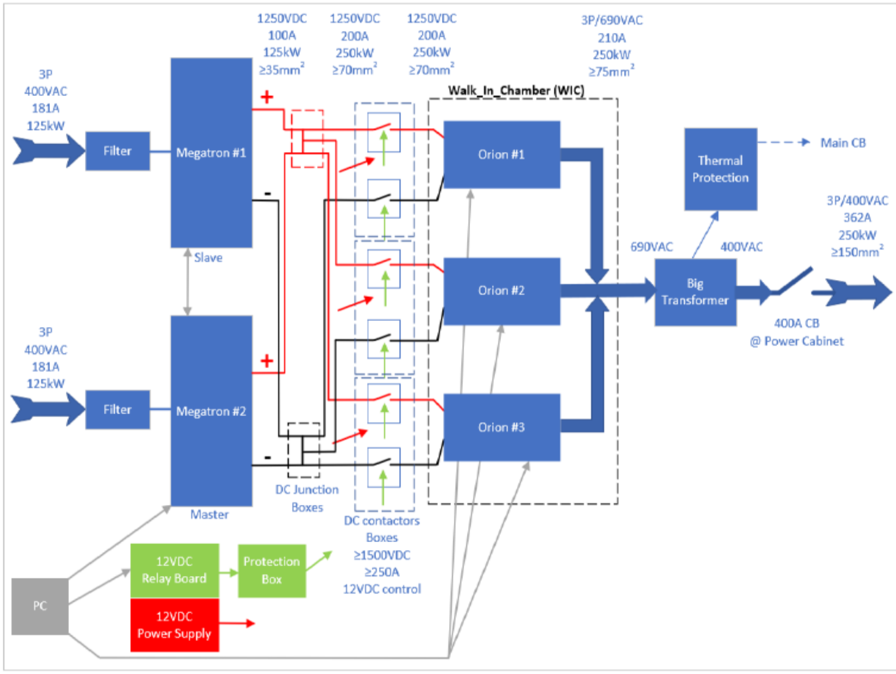


Figure 4-3 Setup design for thermal cycle and damp heat testing conducted on TerraMax inverters

Damp Heat (DH) Test: A 32-day damp-heat test was conducted using three inverters (two North American and one international variant). Units were subjected to 85°C temperature and 85% relative humidity in idle mode, alternating with test cycles at 50°C and 20% RH during which the inverters produced 250 kW output. This dual-phase approach prevented condensation while enabling thermal and humidity stress aging. The test simulated approximately 24 years of field aging per an Arrhenius-Peck model. All units completed the test with no functional failures. Post-test analysis found minor surface discoloration and residue but no mechanical or electrical issues. Efficiency deviation was limited to 0.77%, within the acceptable range.

4.3 Regulatory and standards

Companies seeking to certify products for global markets have two main options: self-certification and third-party certification. Self-certification involves companies taking responsibility for ensuring their products comply with relevant standards and regulations, while third-party certification entails accredited organizations conducting thorough testing and evaluation to certify compliance. In North America, products require certification by a Nationally Recognized Testing Laboratory (NRTL). This section describes the standards to which the TerraMax PV inverters are certified and the regulations with which it must comply.

4.3.1 Applicable standards

In North American markets, UL 1741 is the crucial standard for ensuring the safety and compliance of inverters, converters, controllers, and interconnection system equipment used with distributed energy resources. This standard aligns with IEEE 1547, which focuses on interconnecting distributed resources with electric power systems. UL 1741 certification is typically required for power converters that interface with the utility grid in residential, commercial, or utility-scale applications. The certification process involves rigorous design inspections and testing, with particular challenges related to anti-islanding, grid protection, surge, and Electro-Magnetic Interference (EMI) testing requirements. Table 4-1 and Table 4-2 list the major testing standards for North America and Europe & ROW, respectively.

Table 4-1 Testing Standards and Requirements for North America

Standard	Title
UL 1741	Standard for Safety Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources
UL 1741 SA	Supplement to UL 1741 addressing test requirements for "Smart Inverter" functions required for CA Rule 21 compliance
UL 1741 SB	Supplement SB will directly refer to IEEE 1547.1-2020 and will be the only test procedure to certify IEEE 1547-2018 compliance.
IEEE 1547	Standard for Interconnecting Distributed Resources with Electric Power Systems
CSA C22.2 NO. 107.1-01	Safety Requirements for General Use Power Supplies (Canada)

Table 4-2 Testing Standards and Requirements for Europe and ROW

Standard	Title
IEC 62477	Safety requirements for power electronic converter systems and equipment
IEC 61000-6-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment
VDE-AR-N4110:2018	Technical Connection Rules for Medium-Voltage
G99	Requirements for the connection of generation equipment in parallel with public distribution networks (required in United Kingdom)
EN50549-2	Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network - Generating plants up to and including Type B
EN55011:2016 and CISPR 11	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
CEI-016	Regulation for the Italian electricity market

4.3.2 Regulatory test reports and certifications

DNV received the Certificates of Conformity issued by SGS stating compliance of SE330K inverter with VDE-AR-N 4110:2018 and VDE-AR-N 4120-2018, as shown in Figure 4-4. The certificate to conformance to EN 50549-2:2019+AM:2023 and EN 50549-10:2022 is shown in Figure 4-5. The certificate of conformance to EMC standards is shown in Figure 4-6. The certificate of conformance of SE300K and SE330K models to IEC 62109-1:2010 and IEC 62109-2:2011 standards issued by Bureau Vertias is shown in Figure 4-7.

DNV has received Certificates of Conformity from Intertek, confirming compliance with UL 1741 3rd Edition Supplement SB for grid support and interoperability functions. The certification also verifies adherence to IEEE 1547-2018, IEEE 1547a-2020, and IEEE 1547.1-2020 standards. Additionally, interoperability functions are certified under UL 1741 3rd Edition Supplement SB and IEEE 1547-2018 / IEEE 1547.1-2020, utilizing the SunSpec Modbus communication protocol. This certificate is for TerraMax models for NAM (SE250KUS, SE285KUS, and SE330KUS). The authorization to mark showing the conformance is shown in Figure 4-8. DNV has also received Certificate of Conformity to FCC CFR 47 Party 15 Subpart B and ANSI C63.4:2014 for TerraMax models for NAM from ILAC MRA, as shown in Figure 4-9.

005-PROD

CEBEC

SGS

Unit Certificate / *Einheitenzertifikat*	No.: 2621-0429-A-CER Signed Copy No.1 / *Unterzeichnete Kopie No.1*	
License holder / *Lizenzinhaber*	SolarEdge Technologies Ltd. 1 Hamda street, Herzliya Pituach 4673335 (Israel)	
Manufacturers / *Herstellers*	SolarEdge Technologies Ltd. 2 Hamerkava street, Industrial Zone, Tziporit, Israel	
Power generating unit type / *Typ Erzeugungseinheit*	Grid Support Utility Bidirectional Converter	
	Trademark / Series	SolarEdge / Orion
	Model / *Modell*	SE300K
Technical Data / *Technische Daten*	Maximum Output Power / *Maximale Ausgangsleistung*	297 kVA
	Rated active power / *Bemessungswirkleistung:*	297 kW
	Rated Voltage / *Bemessungsspannung*	690 Vac
	Nominal Frequency / *Nennfrequenz*	50 Hz
	Software version / *Softwareversion*	2.3.132 or higher
Validated Simulation Model / *Validiertes Simulationsmodell*	Reference name: SE300K_v0_1.pfd MD5 Checksum: 47210173ACD666E3E8B5A9DFEB81CB1E Control Reference name: SE_3PHASE.dll Control MD5 Checksum: 4A260735D4E86D4366EE31D8984FC656 Simulation platform: DigSILENT PowerFactory	
VDE application guide / *VDE-Anwendungsregel*	VDE-AR-N 4110: 2018-11. Technical requirements for the connection and operation of customer installations to the medium voltage network (TAR medium voltage) / *VDE-AR-N 4110: 2018-11. Technische Voraussetzungen für den Anschluss und Betrieb von Kundenanlagen an das Mittelspannungsnetz (TAR-Mittelspannung).* VDE-AR-N 4120:2018-11. Technical requirements for the connection and operation of customer installations to the high voltage network (TAR high voltage). *VDE-AR-N 4120: 2018-11. Technische Voraussetzungen für den Anschluss und Betrieb von Kundeninstallationen an das Hochspannungsnetz (TAR-Hochspannung).*	
Certification programme / *Zertifizierungsprogramm*	FGW- Richtlinie TR 8 Rev. 9	
Other applicable standards/guidelines / *Mitgeltende Normen/Richtlinien*	FGW- Richtlinie TR 3 Rev. 25 (including supplement 1, dated on 22/01/2019) and FGW- Richtlinie TR 4 Rev. 9.	

The power generating unit mentioned above meets the requirements of the application guide listed above / *Die oben bezeichnete Erzeugungseinheit erfüllt die Anforderungen der oben aufgeführten Anwendungsregel*

The following restrictions and deviations apply / *Es gelten folgende Einschränkungen und Abweichungen:*

- The certified product does not provide test terminal. A connecting terminal plate has to be installed separately, if necessary.
  Das zertifizierte Produkt bietet kein Prüfklemmleiste. Eine Prüfklemmleiste ist bei Bedarf separat nachzurüsten.

This certification according to ISO/IEC 17065 has been issued on basis of the certification procedure of SGS / *Diese Zertifizierung nach ISO / IEC 17065 wurde auf Basis des Zertifizierungsverfahrens von SGS erteilt.*

The manufacturer has provided proof of certification of the quality management system of his production facility in accordance with ISO 9001 or is subject to production monitoring / *Der Hersteller hat die Zertifizierung seines Qualitätsmanagementsystems seiner Fertigungsstätte nach ISO 9001 nachgewiesen bzw. unterliegt einer Fertigungsüberwachung.*

The certificate comprises the following information / *Das Zertifikat beinhaltet folgende Angaben:*

- Technical data of the power generating unit, the auxiliary equipment used and the software version used / *Technische Daten der Erzeugungseinheit, der eingesetzten Hilfseinrichtungen und der verwendeten Softwareversion.*
- Schematic structure of the power generating unit / *Den schematischen Aufbau der Erzeugungseinheit.*
- Summarized information on the properties of the power generating unit / *Zusammengefasste Angaben zu den Eigenschaften der Erzeugungseinheit.*

The certificate is comprised of 1 page and an Annex of 77 pages. Current revision of this annex is Revision 0 (dated on 11-06-2024). /
Das Zertifikat besteht aus 1 Seite und einem Anhang mit 77 Seiten. Die aktuelle Revision dieses Anhangs ist Revision 0 (vom 11.06.2024).

The certificate is valid until / *Dieses Zertifikat ist gültig bis:* 14-06-2029
Place, Date/ *Ort, Datum:* Brussels, 14-06-2024

Calogero Lana
Certification Manager

SGS Belgium NV – Division SGS CEBEC
Riverside Business Park Bld. Internationalelaan, 55 Build. A. BE-1070 Brussels
Tel. +32 2 556 00 20 / Fax +32 2 556 00 36
The status and validity of the certificate can be checked scanning the QR code above included or through the following web link database:
https://www.sgs.com/en/certified-clients-and-products/electrical-products
This document cannot be reproduced partially

No. 2621-0429-A-CER
Page 1 of 1

Figure 4-4 Certificate of conformity to VDE-AR-N 4110:2018 and VDE-AR-N 4120-2018 for SE330K issued by SGS

SGS

By the product certificate number **No. 2621/0429-G-CER**

Issued to:

License holder:	**SolarEdge Technologies Ltd.** 1 Hamada street, Herzliya Pituach 4673335, Israel	
Trademark:	solaredge	
Factory location:	**SolarEdge Technologies Ltd.** 2 Hamerkava street, industrial Zone, Tziporit, Israel	

It is certified that the product:
Type of product: Three-Phase Photovoltaic Inverter

Model:		**SE330K**
Technical Data:	**Rated Power**	**330 kW**
	Rated Voltage	**690 Vac**
	Rated Frequency	**50 Hz**
	Firmware version	**2.3.132**
	Number of phases	**Three Phase (3/N/PE)**
	Isolation transformer	**No**

Is in compliance with product requirements of the standard:

- **EN 50549-2:2019+AM:2023**: Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network - Generating plants up to and including Type B.

Is in compliance with the requirements of regulation:

- **EN 50549-10:2022**: Requirements for generating plants to be connected in parallel with distribution networks – Part 10: Tests for conformity assessment of generating units.

The above-mentioned product is certified according to the standard EN 50549-2:2019+AM:2023 and is valid to be installed in PV generating plants up to and including Type B to be connected to a MV distribution network. The relation between this European Standard with the relevant Article of COMMISSION REGULATION (EU) 2016/631 (NC RfG) is considered as it is indicated in the annex H of the standard EN 50549-2:2019+AM:2023.

Aforementioned equipment is certified according to SGS internal procedure PE.T-ECPE-54 according to requirements established on standard UNE-EN ISO/IEC 17065.

This certificate is first issued on 17th July 2024
This certificate is valid until the 17th July 2029

Madrid, 17th July 2024

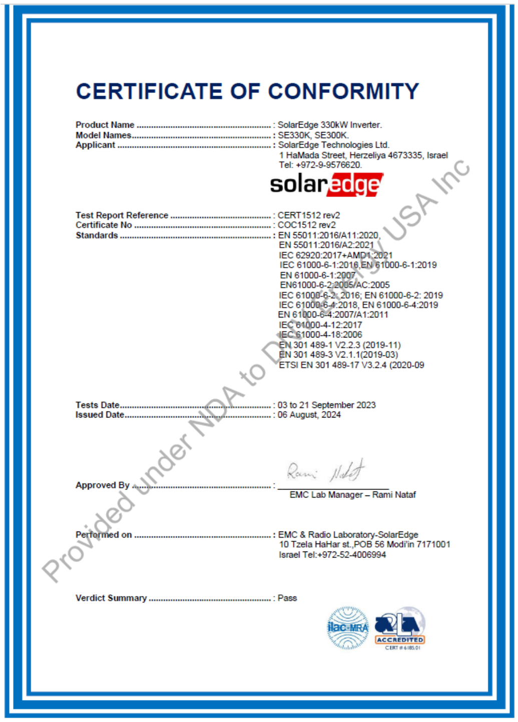
Daniel Arranz Muñiz
Certification Manager

SGS Tecnos, S.A.U. C/ Trespaderne, 29 - 28042 Madrid
This certificate is issued by SGS under its General Conditions for Product Certification at www.sgs.com/terms_and_conditions
The status and validity of the certificate can be checked scanning the QR code above included or through the following web link.
This document cannot be reproduced partially

ENAC

No. 2621/0429-G-CER
Page 1 of 7

Figure 4-5 Certificate of conformity to EN 50549-2:2019+AM:2023 and EN 50549-10:2022 for SE330K issued by SGS



CERTIFICATE OF CONFORMITY

Product Name: SolarEdge 330kW Inverter.
Model Names: SE330K, SE300K.
Applicant: SolarEdge Technologies Ltd.
1 HaMada Street, Herzeliya 4673335, Israel
Tel: +972-9-9576620.

solaredge

Test Report Reference: CERT1512 rev2
Certificate No: COC1512 rev2
Standards: EN 55011:2016/A11:2020,
EN 55011:2016/A2:2021
IEC 62920:2017+AMD1:2021
IEC 61000-6-1:2016,EN 61000-6-1:2019
EN 61000-6-1:2007
EN61000-6-2:2005/AC:2005
IEC 61000-6-2: 2016; EN 61000-6-2: 2019
IEC 61000-6-4:2018, EN 61000-6-4:2019
EN 61000-6-4:2007/A1:2011
IEC 61000-4-12:2017
IEC 61000-4-18:2006
EN 301 489-1 V2.2.3 (2019-11)
EN 301 489-3 V2.1.1(2019-03)
ETSI EN 301 489-17 V3.2.4 (2020-09

Tests Date: 03 to 21 September 2023
Issued Date: 06 August, 2024

Approved By: EMC Lab Manager – Rami Nataf

Performed on: EMC & Radio Laboratory-SolarEdge
10 Tzela HaHar st.,POB 56 Modi'in 7171001
Israel Tel:+972-52-4006994

Verdict Summary: Pass

ilac-MRA A2LA ACCREDITED CERT # 6185.01

Figure 4-6 Certificate of conformity to EMC standards for SE330K issued by ILAC MRA

BUREAU VERITAS

Certificate of compliance

Applicant: SolarEdge Technologies Ltd.
1 HaMada Street
Herzliya 4673335
Israel

Product: Grid-tied photovoltaic inverter

Model: SE300K
SE330K

Ratings:	SE300K	SE330K	--	--
Input DC voltage range [V]:	1200-1500	1200-1500	--	--
Input DC current [A]:	267	267	--	--
Output AC voltage [V]:	690 nom. 587 – 759 50 / 60 Hz	690 nom. 587 – 759 50 / 60 Hz	--	--
Output AC current [A]:	276	276	--	--
Output power [kVA]:	300	330	--	--

The certificate refers to the stated model(s) which passed the tests according to the applicable standard(s):

IEC 62109-1:2010, EN 62109-1:2010, DIN EN 62109-1:2011
Safety of power converters for use in photovoltaic power systems – Part 1: General requirements

IEC 62109-2:2011, EN 62109-2:2011, DIN EN 62109-2:2012
Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters

The safety concept of an aforementioned representative product corresponds at the time of issue of this certificate to the valid safety specifications for the specified use in accordance with the applied rules and standards.

Report number: 21TH0057-IEC62109-1_0
21TH0057-IEC62109-2_0
Certification Program: NSOP-0032-DEU-ZE-V01
Certificate number: U24-0465
Date of issue: 2024-05-29

Certification body
Head of Energy Systems

DAkkS Deutsche Akkreditierungsstelle D-ZE-12024-01-00

Certification body Bureau Veritas Consumer Products Services Germany GmbH accredited according to DIN EN ISO/IEC 17065

Testing laboratory accredited according to DIN EN ISO/IEC 17025

A partial representation of the certificate requires the written approval of Bureau Veritas Consumer Products Services Germany GmbH

BUREAU VERITAS
Consumer Products Services Germany GmbH
Oehleckerring 40, 22419 Hamburg, Germany
Tel: +49 40 74041-0
cps-hamburg@de.bureauveritas.com
www.bureauveritas.de/cps

Figure 4-7 Certificate of conformity to IEC 62109-1 and IEC 62109-2 for SE300K and SE330K issued by Bureau Veritas

DNV

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AUTHORIZATION TO MARK

This authorizes the application of the Certification Mark(s) shown below to the models described in the Product(s) Covered section when made in accordance with the conditions set forth in the Certification Agreement and Listing Report. This authorization also applies to multiple listee model(s) identified on the correlation page of the Listing Report.

This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant: SolarEdge Technologies Ltd
Address: 1 Ha'Mada St.
Herzeliya 4673335
Country: Israel

Manufacturer: Jabil Circuit (Guangzhou) LTD
Address: DEV EAST DISTRICT
128 JUN CHENG RD
GUANGZHOU
GUANGDONG 510530
Country: China

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Intertek Testing Services NA, Inc., Cortland, NY

Control Number: *4004590* **Authorized by:** for L. Matthew Snyder, Certification Manager

C US LISTED Intertek

This document supersedes all previous Authorizations to Mark for the noted Report Number.

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Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Grid Support Utility Interactive Inverters and Converters Based Upon IEEE 1547:2018 & IEEE 1547.1:2020 - Supplement SB to UL 1741:2021 Ed.3 - Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources [UL 1741:2021 Ed.3 (Supplement SB)] Power Conversion Equipment (R2021) [CSA C22.2#107.1:2016 Ed.4]
Product:	Grid Support Utility Interactive Non-Isolated Photovoltaic Inverter
Brand Name:	SolarEdge
Models:	SE330KUS, SE250KUS, SE285KUS.

ATM for Report 104384166CRT-001 Page 1 of 4 ATM Issued: 8-Nov-2024
ED 16.3.15 (1-Jul-2022) Mandatory

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AUTHORIZATION TO MARK

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Applicant: SolarEdge Technologies Ltd
Address: 1 Ha'Mada St.
Herzeliya 4673335
Country: Israel

Manufacturer: SolarEdge Technologies Inc.
Address: 447 Ingenuity Avenue Suite 120, Bldg. B,
Sparks, NV 89441
Country: USA

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Intertek Testing Services NA, Inc., Cortland, NY

Control Number: *4004590* **Authorized by:** for L. Matthew Snyder, Certification Manager

C US LISTED Intertek

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Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Grid Support Utility Interactive Inverters and Converters Based Upon IEEE 1547:2018 & IEEE 1547.1:2020 - Supplement SB to UL 1741:2021 Ed.3 - Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources [UL 1741:2021 Ed.3 (Supplement SB)] Power Conversion Equipment (R2021) [CSA C22.2#107.1:2016 Ed.4]
Product:	Grid Support Utility Interactive Non-Isolated Photovoltaic Inverter
Brand Name:	SolarEdge
Models:	SE330KUS, SE250KUS, SE285KUS.

ATM for Report 104384166CRT-001 Page 2 of 4 ATM Issued: 8-Nov-2024
ED 16.3.15 (1-Jul-2022) Mandatory

Provided under NDA to DNV Energy USA Inc

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Applicant: SolarEdge Technologies Ltd
Address: 1 Ha'Mada St.
Herzeliya 4673335
Country: Israel

Manufacturer: SolarEdge Sella1
Address: 2 Hamerkava St. PO Box 70004 Ziporit
Industrial Zone
Nof Hagalil, 1789058
Country: Israel

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Intertek Testing Services NA, Inc., Cortland, NY

Control Number: *4004590* **Authorized by:** for L. Matthew Snyder, Certification Manager

C US LISTED Intertek

This document supersedes all previous Authorizations to Mark for the noted Report Number.

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Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Grid Support Utility Interactive Inverters and Converters Based Upon IEEE 1547:2018 & IEEE 1547.1:2020 - Supplement SB to UL 1741:2021 Ed.3 - Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources [UL 1741:2021 Ed.3 (Supplement SB)] Power Conversion Equipment (R2021) [CSA C22.2#107.1:2016 Ed.4]
Product:	Grid Support Utility Interactive Non-Isolated Photovoltaic Inverter
Brand Name:	SolarEdge
Models:	SE330KUS, SE250KUS, SE285KUS.

ATM for Report 104384166CRT-001 Page 3 of 4 ATM Issued: 8-Nov-2024
ED 16.3.15 (1-Jul-2022) Mandatory

Provided under NDA to DNV Energy USA Inc

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This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant: SolarEdge Technologies Ltd
Address: 1 Ha'Mada St.
Herzeliya 4673335
Country: Israel

Manufacturer: Flextronics America, LLC
Address: 12455 Research Boulevard,
Austin Texas, 78759
Country: USA

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Intertek Testing Services NA, Inc., Cortland, NY

Control Number: *4004590* **Authorized by:** for L. Matthew Snyder, Certification Manager

C US LISTED Intertek

This document supersedes all previous Authorizations to Mark for the noted Report Number.

This Authorization to Mark is for the exclusive use of Intertek's Client and is provided pursuant to the Certification agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this Authorization to Mark. Only the Client is authorized to permit copying or distribution of this Authorization to Mark and then only in its entirety. Use of Intertek's Certification mark is restricted to the conditions laid out in the agreement and in this Authorization to Mark. Any further use of the Intertek name for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. Initial Factory Assessments and Follow up Services are for the purpose of assuring appropriate usage of the Certification mark in accordance with the agreement, they are not for the purposes of production quality control and do not relieve the Client of their obligations in this respect.

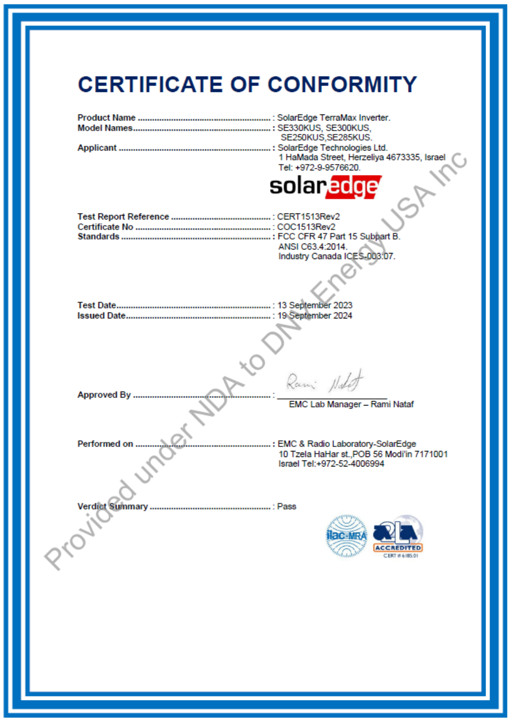
Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Grid Support Utility Interactive Inverters and Converters Based Upon IEEE 1547:2018 & IEEE 1547.1:2020 - Supplement SB to UL 1741:2021 Ed.3 - Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources [UL 1741:2021 Ed.3 (Supplement SB)] Power Conversion Equipment (R2021) [CSA C22.2#107.1:2016 Ed.4]
Product:	Grid Support Utility Interactive Non-Isolated Photovoltaic Inverter
Brand Name:	SolarEdge
Models:	SE330KUS, SE250KUS, SE285KUS.

ATM for Report 104384166CRT-001 Page 4 of 4 ATM Issued: 8-Nov-2024
ED 16.3.15 (1-Jul-2022) Mandatory

Provided under NDA to DNV Energy USA Inc

Figure 4-8 Certificate of conformity to UL 1741:2021 for TerraMax models for NAM issued by Intertek


CERTIFICATE OF CONFORMITY

Product Name: SolarEdge TerraMax Inverter.
Model Names: SE330KUS, SE300KUS, SE250KUS,SE285KUS.
Applicant: SolarEdge Technologies Ltd.
1 HaMada Street, Herzeliya 4673335, Israel
Tel: +972-9-9576620.

Test Report Reference: CERT1513Rev2
Certificate No: COC1513Rev2
Standards: FCC CFR 47 Part 15 Subpart B.
ANSI C63.4:2014.
Industry Canada ICES-003:07.

Test Date: 13 September 2023
Issued Date: 19 September 2024

Approved By: Rami Nataf
EMC Lab Manager – Rami Nataf

Performed on: EMC & Radio Laboratory-SolarEdge
10 Tzela HaHar st.,POB 56 Modi'in 7171001
Israel Tel:+972-52-4006994

Verdict Summary: Pass

ACCREDITED
CERT # 6185.01

Figure 4-9 Certificate of conformity to FCC CFR 47 Party 15 Subpart B and ANSI C63.4:2014 issued by ILAC MRA

4.3.3 NRTL test results

DNV reviewed the test reports for the SolarEdge TerraMax PV inverter series. The test reports provide detailed findings on its compliance with various standards related to safety, operational efficiency, and compatibility with electrical networks.

IEC 62909-1 and IEC 62909-2 Compliance:

- The SolarEdge SE300K and SE330K inverters were tested in accordance with IEC 62909-1 and IEC 62909-2, which specify general requirements and functional characteristics for bidirectional power converters used with energy storage systems connected to the grid. Testing verified the inverters' capability to manage bidirectional power flow and maintain voltage, current, and functional operation within acceptable tolerances during dynamic transitions.
- The tests were conducted by Bureau Veritas CPS Germany GmbH, and the results confirmed full compliance with both parts of the standard. The inverters met all safety, control, and power interface requirements, supporting their suitability for integration into grid-connected photovoltaic and storage systems.

IEC 62109-1 and IEC 62109-2 Safety Compliance:

- SolarEdge TerraMax inverters underwent testing to IEC 62109-1 and IEC 62109-2 standards, which cover general safety and specific requirements for PV power converters. The evaluation included checks for electrical insulation, protection against electric shock, abnormal operation handling, and verification of accessible parts under fault conditions.
- Testing confirmed that the inverters provide appropriate isolation, proper grounding, and effective fault protection measures. Both input and output protections were validated through simulated faults and isolation resistance tests, and no safety violations or failures were recorded.

UL 1741 Compliance:

- The TerraMax inverters were tested to UL 1741:2010 Ed.2, including revisions up to February 2020. The test campaign, conducted by Intertek Testing Services NA, included performance, abnormal operation, dielectric withstand, and temperature rise testing.
- Results showed that the inverters satisfied all applicable criteria for grid-interactive operation, with no deviations from the required specifications. The findings support the inverter's compliance with North American safety standards for distributed energy systems.

FCC Part 15 Subpart B Compliance:

- Electromagnetic emissions testing was performed on the TerraMax inverter to evaluate compliance with FCC CFR 47 Part 15 Subpart B, Class A limits. Conducted and radiated emissions were measured, and the unit met all specified limits for industrial environments.
- The testing was performed by Nemko Canada Inc., and no emissions above the regulatory thresholds were observed during evaluation.

EMC Compliance – EN 55011 and IEC 61000 Series:

- EMC testing was conducted to assess the inverter's immunity and emission characteristics under EN 55011:2016 + A1:2017 Class A and IEC 61000-6-2:2016 standards. The tests included electrostatic discharge (ESD), radiated RF immunity, EFT (electrical fast transients), and surge immunity.
- Results confirmed that the inverter maintained functional performance throughout the test sequences and did not emit interference beyond prescribed limits. All criteria for emissions and immunity were met without failure.

4.4 Quality systems evaluation

Leading power converter manufacturers implement Quality Management Systems (QMS) to adhere to established industry standards in managing their operations, product development, and manufacturing processes. DNV places considerable importance on evaluating the certification and practical implementation of QMS systems as a key indicator of product quality and reliability. This assessment of QMS systems helps determine the manufacturer's dedication to upholding high standards and providing trustworthy products. It serves as a crucial aspect in evaluating the overall quality and dependability of the products being assessed.

SolarEdge is certified to ISO 9001:2015 for its QMS, to ISO 14001:2015 for its environmental management system, and to ISO 45001:2018 for its occupational health and safety management system. The certificates for these are shown in Figure 4-10 through Figure 4-12.

Institute of Quality & Control

CERTIFICATE IQC
Institute of Quality & Control

No. I28469K

This is to certify that
The Quality Management System of

Solaredge Technologies Ltd
Attached appendix site

Was audited by IQC and found to be
in compliance with the requirements of the standard:

ISO 9001:2015

This certificate is valid for the following scope of activities:
Design, Development, Production, Sales and Service to inverting solutions and products for solar PV photovoltaic system supported by Information & cloud service security. Software engineering in accordance with ISO 90003:2018 guidelines. Products portfolio refer to SolarEdge Power Optimizer, SolarEdge Inverter, SolarEdge Solutions and SolarEdge Monitoring Software.

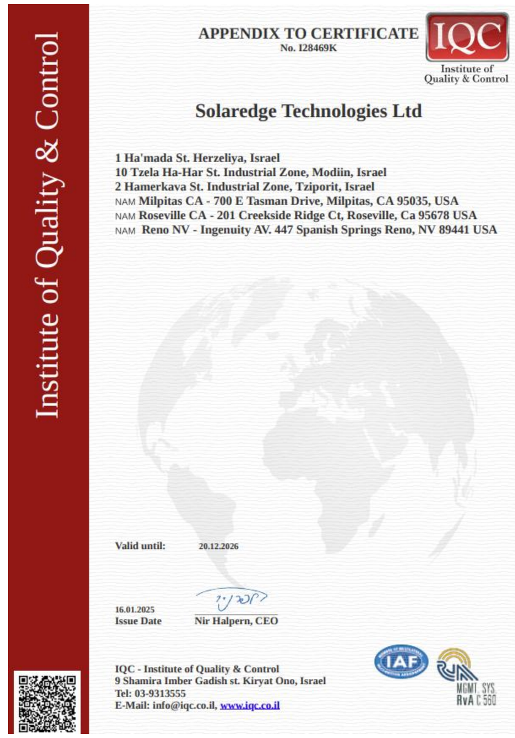
This certificate is valid until:	20.12.2026
Certification cycle will end on:	20.12.2026
Date of previous certification cycle:	20.12.2023
Date of certification decision:	15.01.2025
Date of first approval:	05.01.2015

This certificate is subject to the continuing satisfactory operation of the Management System and periodic auditing by IQC

16.01.2025
Issue Date

Nir Halpern, CEO

IQC - Institute of Quality & Control
9 Shamira Imber Gadish st. Kiryat Ono, Israel
Tel: 03-9313555
E-Mail: info@iqc.co.il, www.iqc.co.il



Institute of Quality & Control

APPENDIX TO CERTIFICATE IQC
No. I28469K
Institute of Quality & Control

Solaredge Technologies Ltd

1 Ha'mada St. Herzeliya, Israel
10 Tzela Ha-Har St. Industrial Zone, Modiin, Israel
2 Hamerkava St. Industrial Zone, Tziporit, Israel
NAM Milpitas CA - 700 E Tasman Drive, Milpitas, CA 95035, USA
NAM Roseville CA - 201 Creekside Ridge Ct, Roseville, Ca 95678 USA
NAM Reno NV - Ingenuity AV. 447 Spanish Springs Reno, NV 89441 USA

Valid until: 20.12.2026

16.01.2025
Issue Date

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Figure 4-10 SolarEdge's ISO 9001:2015 certification

Institute of Quality & Control

CERTIFICATE IQC
Institute of Quality & Control

No. I28518K

This is to certify that
The Environmental Management System of

Solaredge Technologies Ltd
Attached appendix site

Was audited by IQC and found to be
in compliance with the requirements of the standard:

ISO 14001:2015

This certificate is valid for the following scope of activities:
Design, Development, Production, Sales and Service to inverting solutions and products for solar PV photovoltaic system supported by Information and cloud service security. Products portfolio refer to SolarEdge Power Optimizer, SolarEdge Inverter, SolarEdge Solutions and SolarEdge Monitoring Software

This certificate is valid until:	20.12.2026
Certification cycle will end on:	20.12.2026
Date of previous certification cycle:	20.12.2023
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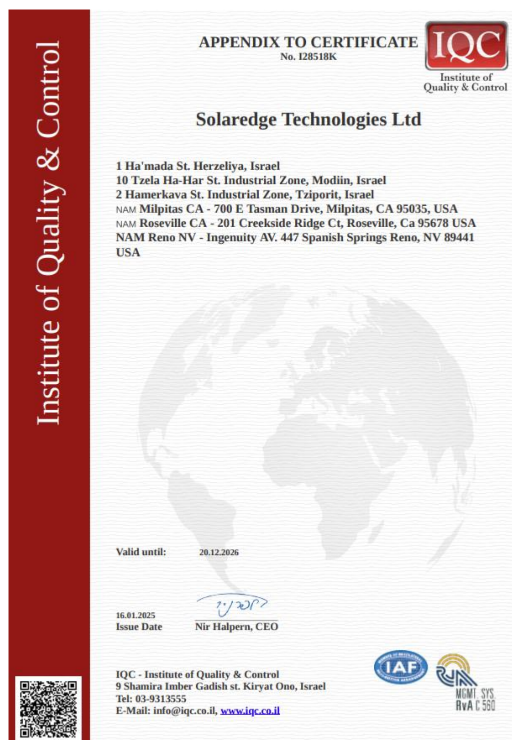

Institute of Quality & Control

APPENDIX TO CERTIFICATE IQC
No. I28518K
Institute of Quality & Control

Solaredge Technologies Ltd

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Figure 4-11 SolarEdge's ISO 14001:2015 certification

Institute of Quality & Control

CERTIFICATE

No. I28517K

IQC Institute of Quality & Control

This is to certify that
The Occupational Health Safety Management System of

Solaredge Technologies Ltd
Attached appendix site

Was audited by IQC and found to be
in compliance with the requirements of the standard:

ISO 45001:2018

This certificate is valid for the following scope of activities:
Design, Development, Production, Sales and Service to inverting solutions and products for solar PV photovoltaic system supported by Information and cloud service security. Products portfolio refer to SolarEdge Power Optimizer, SolarEdge Inverter, SolarEdge Solutions and SolarEdge Monitoring Software

This certificate is valid until:	13.12.2026
Certification cycle will end on:	13.12.2026
Date of previous certification cycle:	13.12.2023
Date of certification decision:	15.01.2025
Date of first approval:	13.12.2017

This certificate is subject to the continuing satisfactory operation of the Management System and periodic auditing by IQC

16.01.2025
Issue Date

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Institute of Quality & Control

APPENDIX TO CERTIFICATE
No. I28517K

IQC Institute of Quality & Control

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Figure 4-12 SolarEdge's ISO 45001:2018 certification

4.4.1 Quality systems overview

The structure of the QMS implemented at SolarEdge is shown in Figure 4-13. SolarEdge implements an integrated and standards-based Quality, Environmental, Health, and Safety (QEHS) Management System, supported by a structured product lifecycle process. The quality system operates under recognized international frameworks, while the product development lifecycle is defined through phase-gated engineering and manufacturing practices.

Integrated Management System and QEHS Governance: SolarEdge's QEHS policy outlines responsibilities and continuous improvement objectives across the organization. The Vice President of Quality and Reliability is responsible for oversight and reports directly to the CEO, ensuring top-level visibility of quality-related metrics, incident tracking, and improvement plans. The quality system is aligned with:

- ISO 9001 – Quality management
- ISO 14001 – Environmental management
- ISO 45001 – Occupational health and safety
- ISO 27001 – Information security
- ISO 17025 – Laboratory testing and calibration

Key operational practices include Total Quality Management (TQM), PDCA (Plan-Do-Check-Act) cycles, and Corrective and Preventive Action (CAPA) systems. Continuous improvement is tracked through internal audits, performance indicators, and nonconformance analysis. SolarEdge sets measurable objectives around:

- Customer satisfaction
- Product and process reliability
- Cost efficiency (e.g., $/W reduction)
- Risk mitigation and traceable corrective action

The safety program encompasses ergonomic accommodations, PPE provisioning, and job-specific hazard training, supported by periodic internal and external audits. Environmental commitments include minimizing waste, managing hazardous materials, and reducing greenhouse gas emissions.

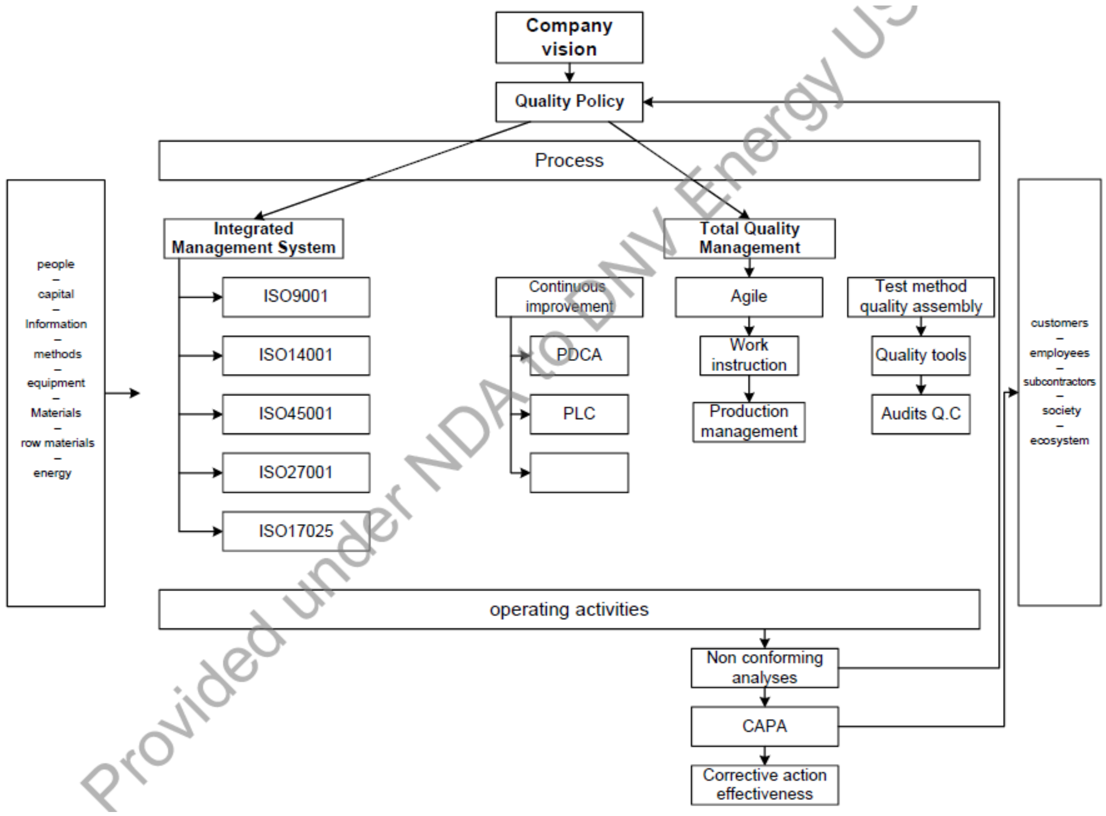

Figure 4-13 Structure of the quality management system implemented at SolarEdge

Product Lifecycle and Design Quality Controls

The SolarEdge Product Lifecycle Control (PLC) framework defines the structured path of development from concept to mass production. This includes multidisciplinary design input, detailed testing protocols, certification coordination, and production readiness assessments. The lifecycle phases include:

- Feasibility and Requirements Definition: Inputs from marketing, certification, testing, and manufacturing are consolidated into system and board-level specifications.
- Prototype and Development Phases: Early-stage design validation includes DFM (Design for Manufacturability), DFT (Design for Test), layout reviews, and environmental simulations (e.g., thermal, IP rating).

- Certification and System Integration: Regulatory requirements are reviewed in parallel with final board integration and embedded software development. Certification tests are scheduled and monitored through coordinated plans.
- NPI and Mass Production: Engineering samples undergo full testing before ramp-up. Factory inspection, tester validation, and cost optimization (layout revisions, sourcing reviews) are completed.
- Improvement and Support: Post-release updates address field feedback, layout corrections, and supply chain changes. Design reviews and re-approvals are conducted if major changes occur.

Control tools throughout the lifecycle include:

- Board-level and mechanical design reviews
- Test procedure development for system and board
- Certification milestone tracking
- Bill of Materials (BOM) accuracy thresholds (90%, 100%)
- Design for environmental constraints and field reliability

Together, the SolarEdge quality system and product lifecycle framework reflect an end-to-end approach that integrates quality assurance, regulatory compliance, environmental responsibility, and continuous improvement throughout product design, manufacturing, and operational phases.

4.4.2 Quality manuals

DNV reviewed SolarEdge's Quality, Environmental, Occupational Health & Safety, and Information Security Management Systems Manual. The Quality Manual typically is written to meet ISO 9001 requirements. DNV generally comments on the level of effort to create the manual. A 16-page manual will meet minimum requirements while providing limited information about the details of the system.

SolarEdge provided a 56-page manual, supporting documentation, quality assurance flowchart, and the procedures and actions for mitigations. DNV notes the quality management to be detailed and with references. The documentation is acceptable and appears well-maintained and has been regularly updated since the first edition in September 15, 2011.

4.5 Product field history

DNV places a strong emphasis on assessing the field history of power converter products as a crucial element in their review process. This field history evaluation considers several key factors:

- Population Size: The size of the installed population of power converters is a significant factor. A larger population provides more data points for evaluating reliability.
- Duration of Operation: The length of time the power converters have been in operation is considered. This duration helps identify trends in reliability over time.
- Field Failures: The number and types of field failures that have occurred are assessed. This data helps in understanding the reliability challenges faced by the product.

- Documentation and Learning: DNV also examines the processes implemented by the manufacturer for documenting and learning from field failures. This proactive approach to addressing issues is a valuable indicator of reliability management.

DNV recognizes two significant milestones when assessing field performance:

- First Year of Operation: After one year of field operation, issues related to infant mortality and early latent defects should have surfaced and been addressed. This early reliability performance often provides insights into long-term reliability trends. Field failure rates can be relatively high in the initial months but should decrease significantly by the end of the first year.
- Multiple Annual Cycles: The second milestone occurs after the power converters have gone through multiple annual cycles in various environments. This phase is characterized by random failures and potentially wear-out failures in individual components. It provides insights into the long-term reliability and robustness of the product.

In summary, DNV's evaluation of field history is a comprehensive process that considers population size, duration of operation, field failures, and the manufacturer's approach to issue documentation and learning. This assessment helps gauge the overall reliability and performance of power converter products throughout their lifecycle.

DNV recognizes that the H1300 and H1500 power optimizers as well as the TerraMax series PV inverters reviewed in the report are new products without an established field history. However, DNV expects the product to follow a typical trend observed in new products. Early reliability tends to be indicative of long-term reliability, meaning that a well-designed and well-manufactured converter that proves reliable in the short term is likely to maintain its reliability over an extended period. Initial field failure rates may be relatively high in the early months after installation but should decline, with the goal of reaching less than a 1.5% failure rate by the end of the first year, particularly for the inverters. This emphasizes the importance of achieving early reliability in new inverter products to ensure their long-term dependability.

5 MANUFACTURING FACTORY VISIT

DNV conducted a virtual visit to SolarEdge's manufacturing facility to observe the manufacturing process and quality control documentation employed by SolarEdge. A virtual visit of the factory was conducted by DNV on April 9th, 2025 to confirm these processes are sufficiently carried out onsite. DNV's manufacturing and quality review assesses the following, among other aspects:

- The manufacturing facility is compliant with industry requirements and has obtained the necessary certifications.
- The manufacturing process aligns with industry standards.

DNV reviewed documentation provided by SolarEdge and virtually visited the SolarEdge factory to witness the manufacturing process. The products under review for this manufacturing visit were the SolarEdge Terramax^{TM} PV inverter series and H series optimizers. The SolarEdge personnel that attended the visit included the Lead of Business, Sales, Plant Management, Manufacturing, and Quality Assurance.

The main contacts for the virtual visit are:

- Eyal Magal: Factory General Manager
- Maor Gurevich: Production Director
- Aharon Rochman: AVP Quality
- Doron Zuk: Supply Chain & Logistic Director
- Yonatan Velikovich: Terramax Manager

5.1 Factory Description

The Sella 1 manufacturing facility inspected is dedicated to manufacturing SolarEdge inverter products. It is located in Israel, spans 366.2 m², and supports low-volume high-reliability production with a capacity of 2 units per shift. The outside view of the facility is shown in Figure 5-1. The floorplan of the Terramax inverter assembly area is shown in Figure 5-2. The factory has three optimizer production lines. The number of active production lines can vary depending on demand. The floorplan of the H series optimizer production line is shown in Figure 5-3.

Figure 5-1 Front view of the Sella 1 manufacturing facility

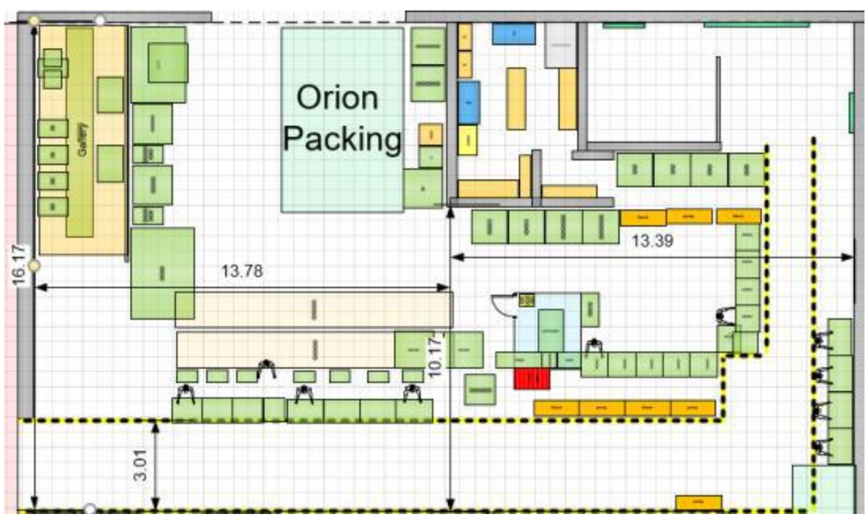

Figure 5-2 Floorplan of assembly area of Terramax series inverters

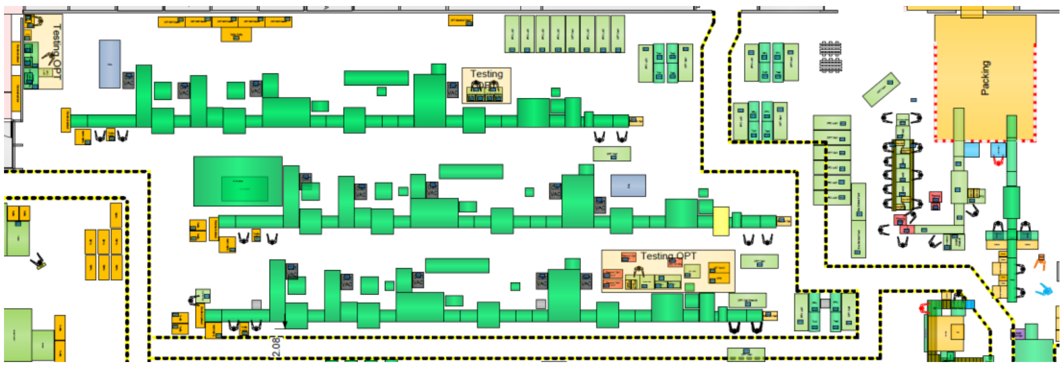

Figure 5-3 Floorplan of H series optimizer production lines

The details of the Sella 1 factory related to the production of Terramax PV inverters and H series optimizers are summarized in Table 5-1.

Table 5-1 Sella 1 manufacturing facility summary

Parameter	Specification
Address	Hamerkava Street 2, Industrial Zone Ziporit, Nof HaGalil, Israel
Factory size	Around 10,060m^2
Factory capacity	2 units per shift for TerraMax PV inverters 2000 units in each production line per shift for H series power optimizers

5.2 Quality systems evaluation

The site is covered under SolarEdge's corporate QESHLI framework, with ISO certifications for Quality (9001:2015), Environmental (14001:2015), Occupational Health & Safety (45001:2018), Information Security (27001), and Lab Quality (17025). Internal audit results from Nov 2023 confirm zero major non-conformities under ISO 9001.

At SolarEdge, the Agile Product Lifecycle Management (PLM) system is used to manage BOMs (Bills of Materials), engineering changes (ECOs), and all associated product documentation. It ensures that all departments are working from the latest design and procedural revisions.

In SolarEdge’s production line, Automated Test Equipment (ATE) is used at various test stations (e.g., HIPOT, EOL) to validate inverters against electrical safety and functional performance parameters, with results logged automatically.

Manufacturing Execution System (MES) at SolarEdge ensures real-time process control, tracks serial numbers, enforces ESD compliance, and blocks defective units from advancing on the line until resolved. It’s tightly integrated with PLM and ERP.

SolarEdge uses Plan-Do-Check-Act (PDCA) loops during weekly quality reviews. For instance:

- Plan: Identify recurring defects and develop a fix strategy.
- Do: Implement the corrective action.
- Check: Review if the defect rate improved.
- Act: Standardize the fix or revisit the plan if ineffective.

Production is governed by Agile PLM. Documentation, BOMs, ATE scripts, and AI instructions are version-controlled. Manufacturing compliance is ensured through MES enforcement and blocked progress for out-of-spec units. The local Q team includes 41 staff, who run weekly defect review meetings. A PDCA loop evaluates root causes and verifies corrective effectiveness.

The quality department at the Sella 1 manufacturing facility is structured as shown in Figure 5-4

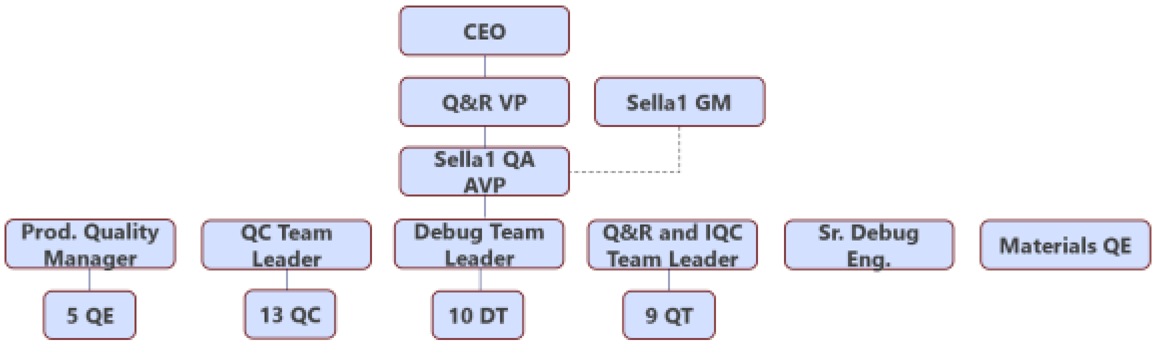

Figure 5-4 Organizational chart of Sella 1 manufacturing facility quality department

DNV notes that the reviewed processes meet expectations.

5.3 Supply Chain Management and Incoming Quality Control

SolarEdge's supply chain and material quality control system is structured to support reliability in manufacturing by tightly integrating supplier management, component qualification, and inspection workflows with the company's ERP and PLM platforms. The process is governed through controlled documentation and compliance procedures formalized under DOC-PR-00385 (New Manufacturer Approval Process) and enforced via Agile PLM and Priority ERP (transitioning to Oracle).

New suppliers are qualified based on technical, quality, and operational capabilities. The approval process includes submission of a complete qualification package, evaluation by SolarEdge's quality and procurement teams, and on-site audits when applicable. As per DOC-PR-00385, the qualification includes:

- Initial document review (e.g., process controls, certifications)
- Sample part inspection
- Trial order performance
- Audit results (if required)

Approved suppliers are added to the Approved Vendor List (AVL) maintained in the Agile PLM system. Supplier performance is monitored continuously via metrics such as IQC defect rates, on-time delivery, and responsiveness to Supplier Corrective Action Requests (SCARs). Suppliers with repeated quality issues may be disqualified, and their parts blocked at procurement level through ERP integration.

SolarEdge procurement is Material Requirements Planning (MRP)-driven, with material requirements planning calculated in the Enterprise Resource System (ERP) system based on active BOMs and production forecasts. Engineering Change Orders (ECOs) released through Agile are automatically linked to updated purchase specifications and disseminated to the sourcing team and vendors to ensure material version alignment.

All received components are subjected to Incoming Quality Control (IQC) inspections based on their risk classification. Components are categorized as general, sensitive, or critical, with corresponding inspection plans and sampling levels.

- Mechanical and standard components (e.g., brackets, fasteners) are typically inspected using AQL 1.5 sampling plans.
- Critical components (e.g., chokes, relays, power semiconductors) undergo 100% functional or parametric testing, either at receipt or during in-process validation. For instance, chokes are tested for inductance, insulation resistance, and coil integrity at the receiving facility.
- Cable assemblies and relays may not be 100% tested at incoming, but are functionally validated during system-level testing stages.

Inspection results are logged into the Manufacturing Execution System (MES) and ERP systems. Nonconforming material is blocked in ERP, flagged for hold, and physically quarantined. Disposition decisions are made through a Material Review Board (MRB), which evaluates the severity and recurrence of the issue. Possible outcomes include rework, return to supplier, scrap, or conditional use with engineering approval.

In cases of supplier-caused defects, SolarEdge issues a SCAR detailing the problem and requesting root cause analysis, corrective actions, and verification of effectiveness. If systemic, the event triggers Corrective and Preventive Actions (CAPA) internally, with tracking in the quality system.

This combined view highlights how SolarEdge maintains tight upstream control of material quality, linking supplier qualification, ongoing performance oversight, and rigorous incoming inspection into an integrated and traceable framework.

The supply chain management process and incoming quality control practices are applicable to both TerraMax PV inverters as well as H series power optimizer products.

5.4 Manufacturing overview

Figure 5-5 shows SolarEdge's approach to ensuring quality, reliability, and traceability during actual product build-up. It involves the integration of automated quality processes, real-time decision systems, and critical component inspection—ensuring defects are caught early and yield losses are rapidly addressed.

SolarEdge's manufacturing line incorporates automated quality assurance technologies, minimizing human error and increasing consistency. It is implemented using

- Smart Tools:
    - Torque-controlled automatic screwdrivers with real-time data logging.
    - Automated paste dispensers for thermal interface materials.
    - Barcode/QR code scanners for station-specific instructions and traceability.
- Inline Monitoring:
    - Automated Optical Inspection (AOI) after critical steps (e.g., SMT placement, final assembly).
    - MES blocks unit progression if test or inspection criteria are not met.

Daily yield reports and test station logs are reviewed and Quality Engineers conduct weekly line audits with CAPA tracking if trends emerge.

IQC is applied to key parts whose failure would compromise performance or safety. These critical components include - Power semiconductors (e.g., IGBTs, FETs), magnetic components (e.g., chokes, transformers), and connectors and relays. The inspection techniques involve:

- Electrical validation
- Visual and mechanical dimension checks
- Supplier traceability documents (e.g., COC, lot history)

Nonconforming material is blocked from use and placed in quarantine status. The MRB determines final disposition: rework, return, scrap, or conditional use.

If a sudden drop in yield is detected during production or testing, response protocols are activated immediately. This process involves:

- MES flags affected batches and prevents further processing.
- Engineering, quality, and production convene for triage.
- Investigation starts with test logs, inspection records, and operator notes.

If systemic issues are found, a CAPA is opened, affected ECO or SOP may be revised, and data is fed back to the design and supplier teams for root cause elimination.

The aim of the manufacturing process is to build every unit right the first time, while ensuring traceability, defect containment, and zero escapes to the field. This ensures the downstream testing phase is efficient, and that field failure rates remain low.

The quality, reliability, and traceability practices during actual product build-up are applicable to the TerraMax inverters as well as H series power optimizers.

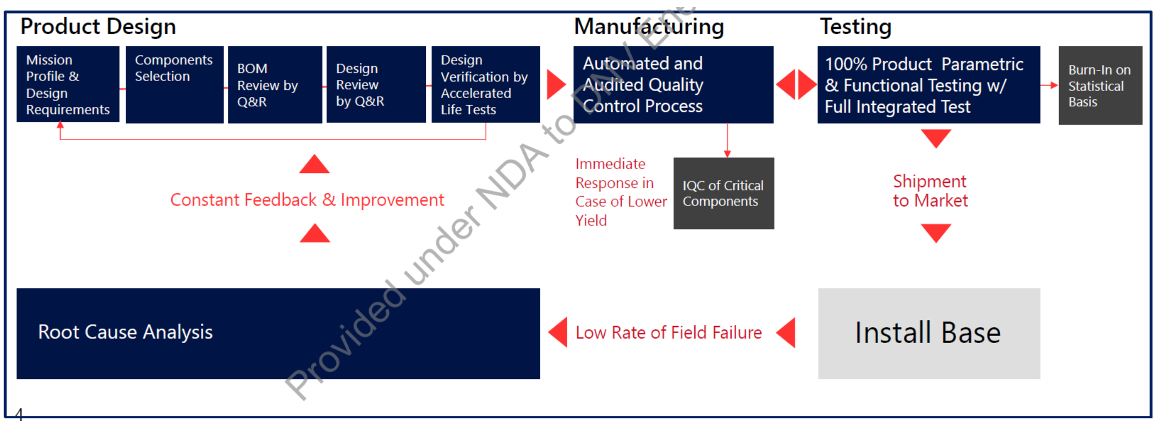

Figure 5-5 SolarEdge's approach to quality, reliability, and traceability

5.5 Manufacturing Process

The manufacturing process at SolarEdge's Sella 1 facility is structured as a continuous flow, supported by automated tools, controlled documentation, and MES-enforced compliance. The site is designed to handle low-volume, high-reliability production, with an emphasis on ensuring traceability, consistency, and operator accountability at every step.

5.5.1 Assembly infrastructure

Assembly operations are performed by trained personnel at designated workstations, each equipped with:

- Barcode scanners to validate product configuration and load the latest work instructions.
- Smart torque tools (e.g., automatic screwdrivers with torque and angle monitoring).
- Automated Optical Inspection (AOI) at key stages (post-placement or mechanical assembly).
- Thermal interface material (TIM) application tools, including jigs to control consistency for IGBT heat sink bonding.

All assembly steps are documented in SOPs maintained in Agile PLM, with version control enforced through MES. The MES system ensures operators follow only the latest released procedure and blocks progression if required steps are missed or inspections are not passed. The pictures of Terramax PV inverter manufacturing line are shown in Figure 5-6 and Figure 5-7.

Each unit and its subassemblies (e.g., chokes, relays) are serialized (see Figure 5-8). Component-level traceability is enforced through scanning at each station. The MES links component IDs with station actions, torque values, test results, and operator IDs. This enables full backward traceability in the event of a field failure or FA (Failure Analysis) requirement.

Figure 5-6 Picture of the Terramax inverter manufacturing line

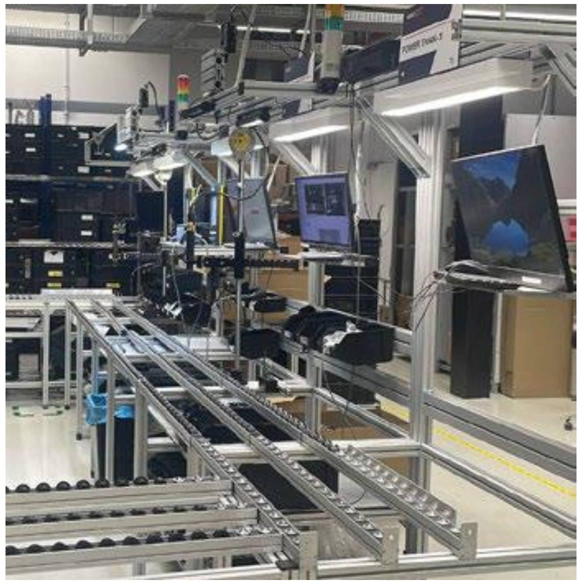

Figure 5-7 Picture of the Terramax inverter power board assembly line

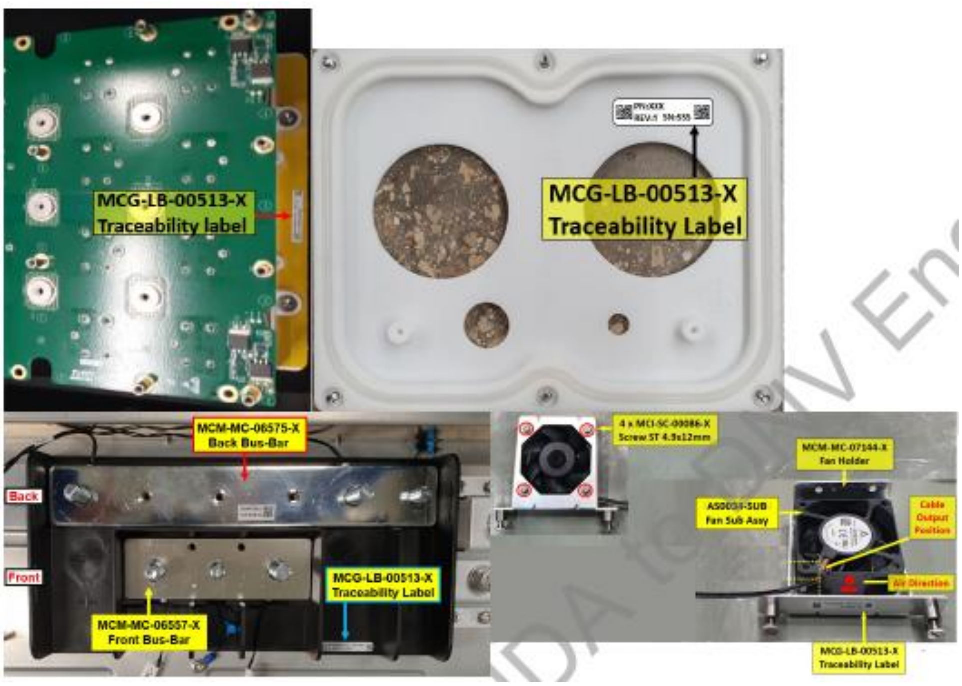

Figure 5-8 Serialization and traceability of each unit and its subassemblies

5.5.2 Operator qualification and training

All new operators undergo structured onboarding including:

- E-learning modules covering safety, quality policies, and product architecture.
- On-the-job training (OJT) under supervision.
- Job rotation to build flexibility and minimize station-level fatigue or skill gaps.

Operators are qualified by area, and MES enforces workstation-level access rights based on training status. Skill matrices are reviewed regularly and updated with new product lines or process changes.

5.5.3 Real-time quality integration

Defects identified at any stage—whether during assembly, visual inspection, or inline testing—are logged immediately in MES and trigger defect blocking and escalation. Operators cannot advance the unit without resolving the failure or submitting it to quality for MRB review. This system provides real-time visibility to line leadership and the quality team, and contributes to weekly PDCA reviews. Multiple control steps are integrated with the process such as:

- Thermal grease application for IGBTs is jig-based to control thickness and coverage (as shown in Figure 5-9).
- Mechanical torque tightening is verified and logged electronically; tools are locked if torque deviations are detected.
- Soldering steps (where applicable) adhere to IPC-A-610 standards. These are performed via automated robotic equipment and are monitored by in-line Automatic Optical Inspection (AOI). Manual touch-up is allowed as rework for minor reject to meet IPC-A-610 standard. The manual touch-up is performed by trained operators and is also subject to IPC-A-610.

The manufacturing process at SolarEdge aims to assemble products as well as continuously validate quality, enforce discipline, and capture process data at every touchpoint. Through integrated tooling, document control, and MES enforcement, the line ensures that no unit can proceed without compliance to build and inspection standards.

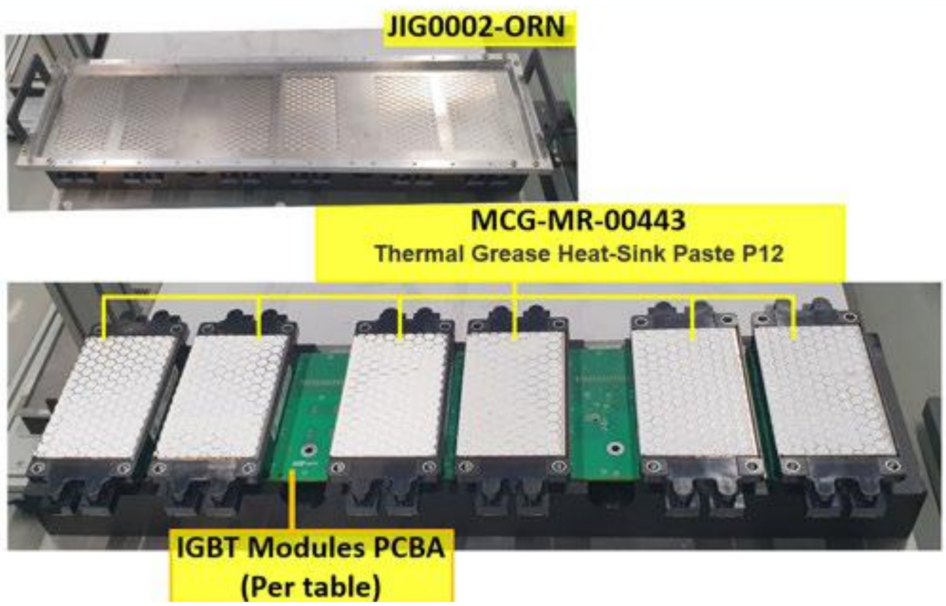

Figure 5-9 Jigs for thermal grease application to IGBTs

The manufacturing process for the H series power optimizers is similar to that described in a previous manufacturing site visit conducted by DNV and can be reviewed in report titled ‘10361427-HOU-R-01-A Solaredge – Technology Review Report’ dated October 18, 2022. The production line for the H-series optimizers are shown in Figure 5-10 and Figure 5-11.

Figure 5-10 Picture of H series production line in Sella I manufacturing facility

Figure 5-11 Picture of H-series production line in Sella I manufacturing facility

5.6 Product Testing and Inspection

SolarEdge's product testing and inspection framework is designed to validate electrical functionality, safety compliance, and performance integrity of each inverter unit prior to shipment. The process is automated and integrated with the MES and test data systems to ensure full traceability and quality control.

5.6.1 End-of-Line testing

Every inverter and optimizer produced at the Sella 1 facility undergoes 100% End-of-Line (EOL) testing. The EOL test station includes:

- Electrical functional verification, ensuring proper output voltages, current regulation, power factor, and internal temperature behavior.
- HIPOT (High Potential) testing, conducted to validate dielectric withstand strength and isolation between high-voltage and grounded circuits.
- Ground Continuity and Insulation Resistance tests, ensuring safety compliance per IEC and UL standards.

Test scripts are version-controlled via Agile PLM and loaded directly into the Automated Test Equipment (ATE) at each station. Test limits are locked and tamper-resistant, ensuring consistency across test sessions. The system also ensures that only the correct test configuration is used per product variant. The test station for HIPOT EOL testing is shown in Figure 5-12.

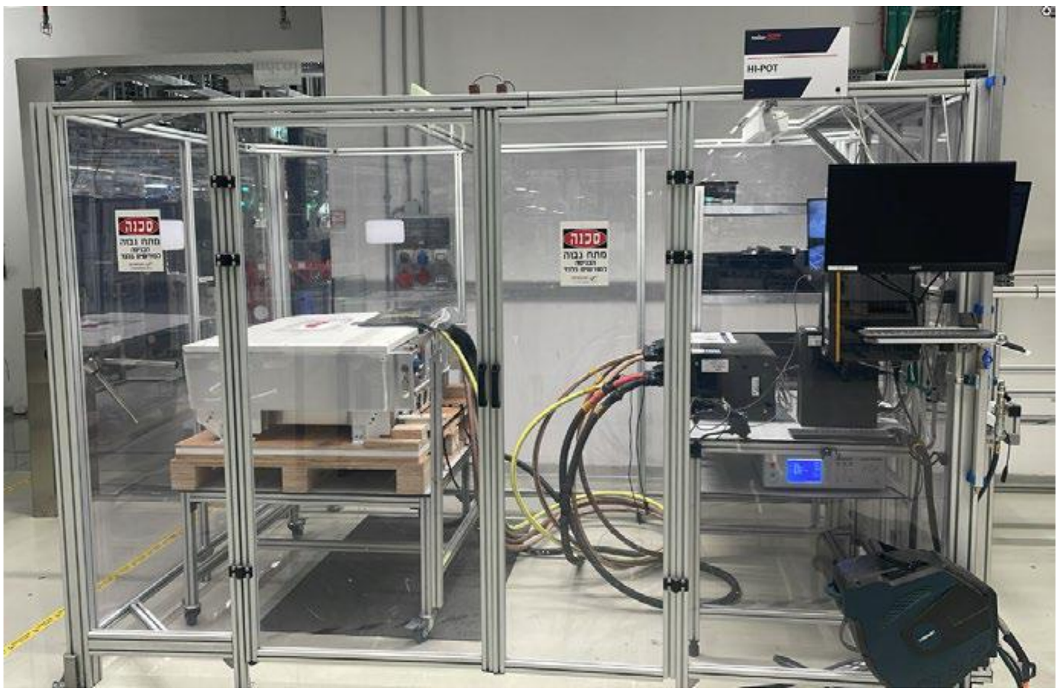

Figure 5-12 Chamber for HIPOT EOL testing

5.6.2 ATE and MES integration

The ATE platforms are integrated with SolarEdge's MES, such that:

- Test results are automatically uploaded and stored in a centralized database.
- If a unit fails any test parameter, MES blocks it from further progression.
- Only units that pass all test stages can be released for final packing and shipping.

The MES records operator ID, fixture ID, timestamp of test, and pass/fail status and error logs. This ensures complete traceability from test results back to assembly data, material lots, and operator activity.

5.6.3 Burn-in testing

A subset of inverters undergo burn-in testing based on a statistical sampling plan. The purpose of burn-in is to detect early-life or infant mortality failures and validate thermal management and power stage behavior under extended stress. The burn-in conditions typically include elevated ambient temperature and operating at nominal load for a fixed duration. Burn-in units are monitored throughout the cycle, and results are analyzed to verify product robustness and detect any systemic issues.

5.6.4 Test equipment calibration

All test instruments used in production (HIPOT testers, multimeters, power analyzers) are subject to scheduled calibration under the site's QMS plan. Calibration certificates are maintained, and the equipment is tagged with due dates. MES checks that calibration is current before allowing a test station to operate.

5.6.5 Field-triggered inspection feedback

Field failure trends and return analysis are regularly reviewed and—when necessary—translated into updated test coverage. For example, if a specific fault mode is detected during Failure Analysis (FA), test coverage is modified via ECO to include additional parameters or tighter thresholds.

SolarEdge's testing and inspection infrastructure ensures that only fully functional and compliant units are released to customers. Through integration with MES, real-time control of pass/fail criteria, and traceability of every tested unit, the company aims to ensure its quality objectives are met at the final stage of production.

5.7 Final Inspection, Packing, and Shipping

The final stage of the manufacturing process at SolarEdge's Sella 1 facility includes a final inspection, followed by packaging according to product-specific requirements, and preparation for shipping with full documentation. This phase is designed to ensure that only fully compliant, correctly assembled, and properly labeled units leave the facility.

5.7.1 Final visual inspection

After a unit passes all automated tests (including End-of-Line, HIPOT, and Functional Testing), it is routed to the final inspection station. Here, trained operators perform a standardized visual and procedural checklist inspection that verifies:

- Completion of all required assembly steps
- Presence and orientation of all mechanical components and fasteners
- Application and positioning of safety and identification labels
- Cleanliness of heat sinks, connectors, and enclosure
- Torque marks and mechanical tamper indicators (where applicable)

The inspection checklist is version-controlled in the Agile PLM system and enforced by MES. Any deviation found at this stage must be resolved before the unit is allowed to proceed.

5.7.2 Packaging

Each unit is packaged following a controlled work instruction that includes:

- Proper placement of the inverter in a cushioned and ESD-safe box

- Inclusion of product documentation, such as the datasheet, user manual, quick installation guide, and certificate of compliance (if required by order)
- Application of handling labels, including unit serial number, product revision and ECO status, weight and center-of-gravity indicators, and forklift lifting zones & orientation arrows.

Packaging materials are specified to withstand expected transportation stress (drop, vibration, moisture) based on the product’s weight class and destination. For multi-unit shipments, palletization follows defined stacking patterns and load constraints, with clear labeling for customs and receiving. A Terramax inverter being packaged is shown in Figure 5-13.

Figure 5-13 Packaging of tested inverter

5.7.3 Shipping preparation

Units ready for shipment are logged into the ERP system, which records final serial number release, packing list generation, and shipping label assignment. MES and ERP records are synchronized to ensure traceability from production through to final delivery. Only units that have passed all test gates, final inspection, and are confirmed as shipped in ERP are released from inventory.

Logistics coordination is performed based on customer order fulfillment data, ensuring correct product allocation and timely dispatch. Export documentation and commercial invoices are managed by the logistics team in accordance with applicable regional and international shipping regulations. A packaged Terramax PV inverter ready for shipping is shown in Figure 5-13.

Figure 5-14 A packaged inverter ready for shipment

SolarEdge's final inspection and shipping process aims to ensure that each product meets physical, procedural, and compliance criteria before leaving the facility. The use of digital traceability, checklists, and controlled packaging workflows aims to support product integrity through delivery.

6 PRODUCT SUPPORT

This section provides information about the service infrastructure for the support of fielded SolarEdge products and SolarEdge products in the sales process.

6.1 Service infrastructure evaluation

SolarEdge has developed a structured service and support framework to ensure high availability and reliability of its TerraMax inverters and associated systems such as the H1300 power optimizers. The support strategy encompasses pre-defined spare parts provisioning, a tiered technical support model, global logistics planning, and certified training programs for system installers and operators. The approach is designed to meet performance restoration expectations under defined Service Level Agreements (SLAs) and aligns with operational reliability targets for utility-scale installations.

Service Level Agreements and Response Commitments: SolarEdge offers SLA-based service models, which include tiered response timelines depending on the severity of the issue. Severity levels are classified as:

- Minor: No production impact (e.g., communications issues)
- Major: Partial production loss (0–60%)
- Critical: High production loss (61–100%) or safety-related failure

Response commitments under the SLA are determined (or tailored) with each customer with consideration to their requirements.

Help desk support via phone, portal, or chat is available during business hours, with a response time target of 15 minutes.

Spare Parts Strategy: Spare parts planning is integrated into SolarEdge's service model to minimize system downtime. Spare parts include both complete inverter units and subassemblies such as:

- Digital boards
- AUX boards and cables
- AC/DC terminal blocks
- Relays, fans, and fuses
- Inverter covers, plates, and switch assemblies

For utility-scale sites, the company recommends:

- 1 inverter per site for systems between 10–30 MW
- 2 inverters per site for systems larger than 30 MW
- 0.5% of installed H1300 power optimizers, up to 200 units, per location

Storage may be managed either onsite or within a 200 km radius. Stock levels are expected to be maintained by the customer unless otherwise arranged. The spare parts strategy includes periodic evaluation based on MTBF data after the first year of operation.

Replacement and Repair Protocols: SolarEdge classifies components into replaceable and non-replaceable categories. Internal kits such as relays, digital boards, and terminal blocks are replaceable by certified SolarEdge Field Service

Engineers (FSEs) only, requiring formal O&M training. Non-replaceable parts include the dc safety switch, dc cap board, and power conversion modules. External parts like inverter covers and fans are field replaceable with appropriate documentation and tools. On-site replacement procedures are supported by standard tools, such as portable cranes, trolleys, and diagnostic jigs. Support also includes access to SaaS-based monitoring and diagnostic platforms for remote performance tracking and issue escalation.

Global Rollout and Support Structure: The TerraMax series product rollout is structured in phases across multiple regions including North America, Europe, Israel, Taiwan, and South Africa. Internal and installer training are conducted in parallel with local product releases. SolarEdge has established dedicated support teams for Tier 1 and Tier 2 response, and provides logistics workflows for product refurbishment, field returns, and disposal. Documentation and installer training resources are provided via a Learning Management System (LMS), and the rollout includes regional distribution of spare parts and support tools. Additional training for communications protocols such as Modbus is incorporated into the release timeline.

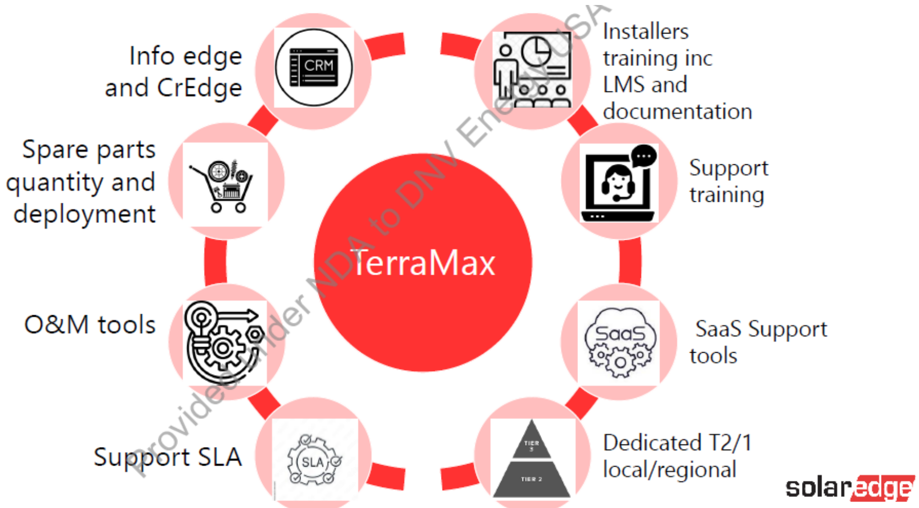

Figure 6-1 Aspects of service infrastructure for TerraMax series

SolarEdge's service infrastructure emphasizes coordinated logistics, pre-allocated parts inventory, certified service personnel, and structured response protocols.

6.2 Warranty evaluation

SolarEdge offers a structured warranty and support program tailored for utility-scale applications, encompassing inverter and power optimizer hardware coverage, performance protection, dedicated support services, and installer training. These services are time-bound and vary depending on the product and support type, with additional provisions for system monitoring and technical escalation.

Hardware Warranty Coverage

- Power Optimizers are covered under a 25-year warranty, which is standard for module-level power electronics (MLPE). This coverage ensures long-term hardware protection against manufacturing or operational failures. The AdvantEdge Enhanced Performance Protection service provides additional coverage for 2 years, during which faulty optimizers are monitored, compensated for lost energy, and replaced. This support is designed to mitigate downtime impact and ensure continued production. Please note that AdvanEdge is a service offered selectively, depending on the customer's needs, and is available for sites above a certain size. Its provision is subject to business requirements and requires specific approval.

- SolarEdge TerraMax Inverters carry a 5-year warranty. The warranty covers hardware failure and is aligned with typical inverter life-cycle maintenance expectations in utility-scale systems. A Proactive Monitoring Service is provided for 1 year. During this period, SolarEdge professionals monitor system performance remotely, generate reports, and assess fleet-wide operational health to minimize downtime and support prompt fault detection. Please note that the reports are provided based on the site size and the customer's specific needs. For some customers, reports may be issued on a quarterly basis.

Technical Support Services

- A Dedicated Technical Account Manager is assigned for 1 year, serving as the primary point of contact and first line of technical escalation. This role supports coordination across design, commissioning, and operational troubleshooting phases.
- A Dedicated Support Line is also provided for 1 year, offering priority access to SolarEdge technical personnel for issue resolution, system diagnostics, and operational support.
- A Basic SLA is available during the same period, ensuring system reliability through predefined service expectations and support availability during business hours.

Installer and Operator Training

To ensure proper deployment and ongoing maintenance capabilities, SolarEdge offers two training programs:

- The EPC Training Program includes digital modules covering design, installation, wiring, commissioning, and system maintenance. Optional on-site training by regional SolarEdge professionals is also available. The total duration is 2 days.
- The O&M Training Program focuses on internal part replacements and system servicing. It includes digital certification training with optional on-site instruction. The duration is 1 day.

DNV views the standard warranty to be typical compared to similar inverters and MLPE.

6.3 Product manuals

DNV reviewed the SolarEdge TerraMax Inverter installation and quick installation guides for European and North American markets. These manuals included:

SolarEdge TerraMax Inverter Installation Guide Version 1.7: This manual offers a comprehensive set of instructions for installing and commissioning the TerraMax inverter in Europe, APAC, and South Africa. It includes procedures for mounting, electrical connections (AC/DC), grounding, communication configuration, and safety compliance. Specific regionally aligned wiring practices and environmental considerations are included.

Installation Guide SolarEdge TerraMax Inverter Version 1.3: Tailored for North American installations, this guide covers all installation and commissioning steps for the TerraMax inverter. It addresses U.S.-specific electrical codes, conduit practices, and labeling standards. Detailed instructions on inverter positioning, communication wiring (CAN, RS-485), and system registration are also provided.

DNV finds all manuals to be well-organized, and quite detailed with many high-resolution graphics to support the text.

7 REFERENCES

[1] CEC, "California Energy Commision," [Online]. Available: https://solarequipment.energy.ca.gov/Home/InverterSolarList. [Accessed 02 June 2025].

ABOUT DNV

We are the independent expert in assurance and risk management. Driven by our purpose, to safeguard life, property and the environment, we empower our customers and their stakeholders with facts and reliable insights so that critical decisions can be made with confidence. As a trusted voice for many of the world's most successful organizations, we use our knowledge to advance safety and performance, set industry benchmarks, and inspire and invent solutions to tackle global transformations.