



# Solar power

## Low-voltage solutions for a safe and reliable photovoltaic system

Power and productivity  
for a better world™

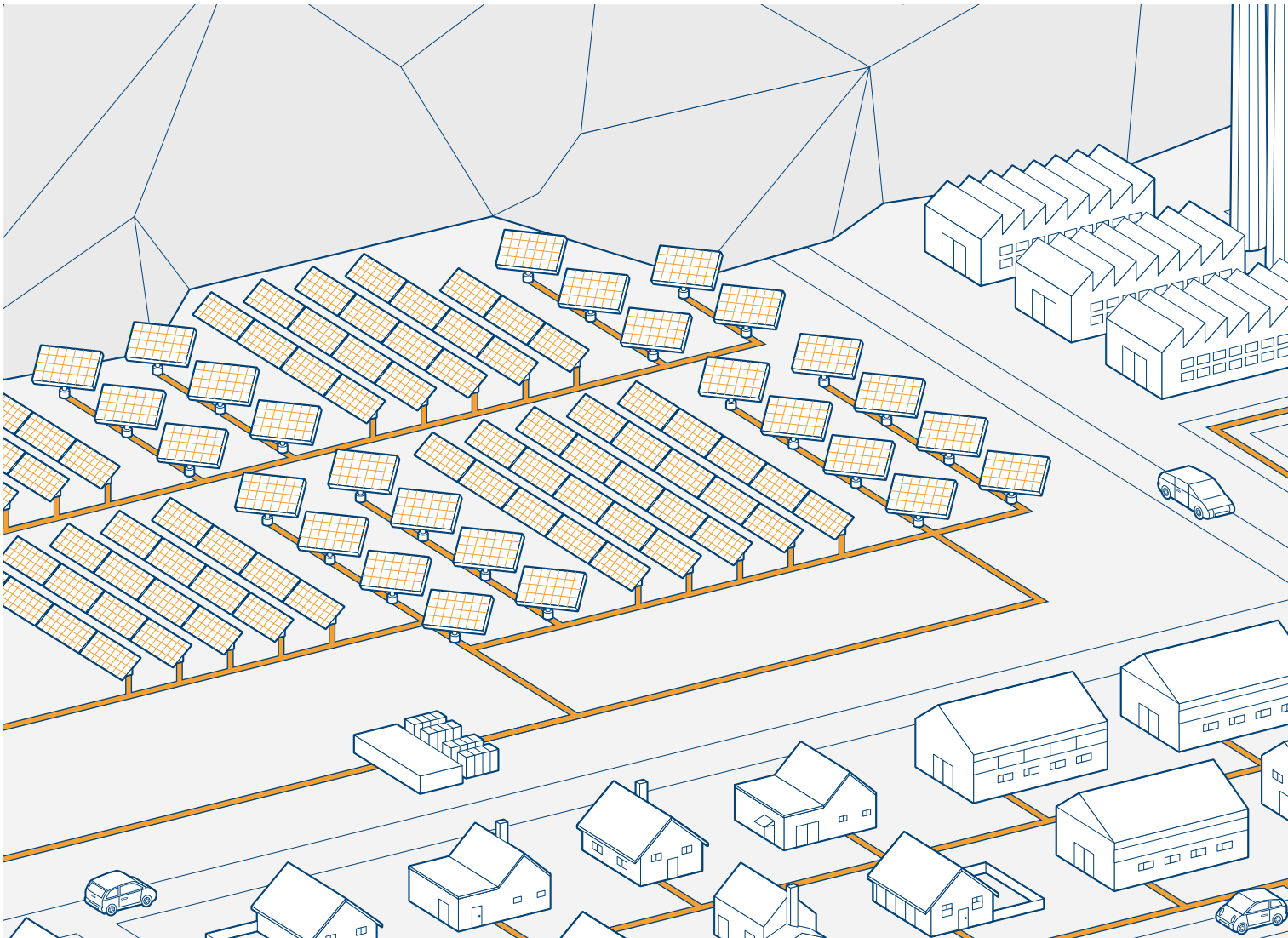


# Clean and safe energy

## Focus on system components

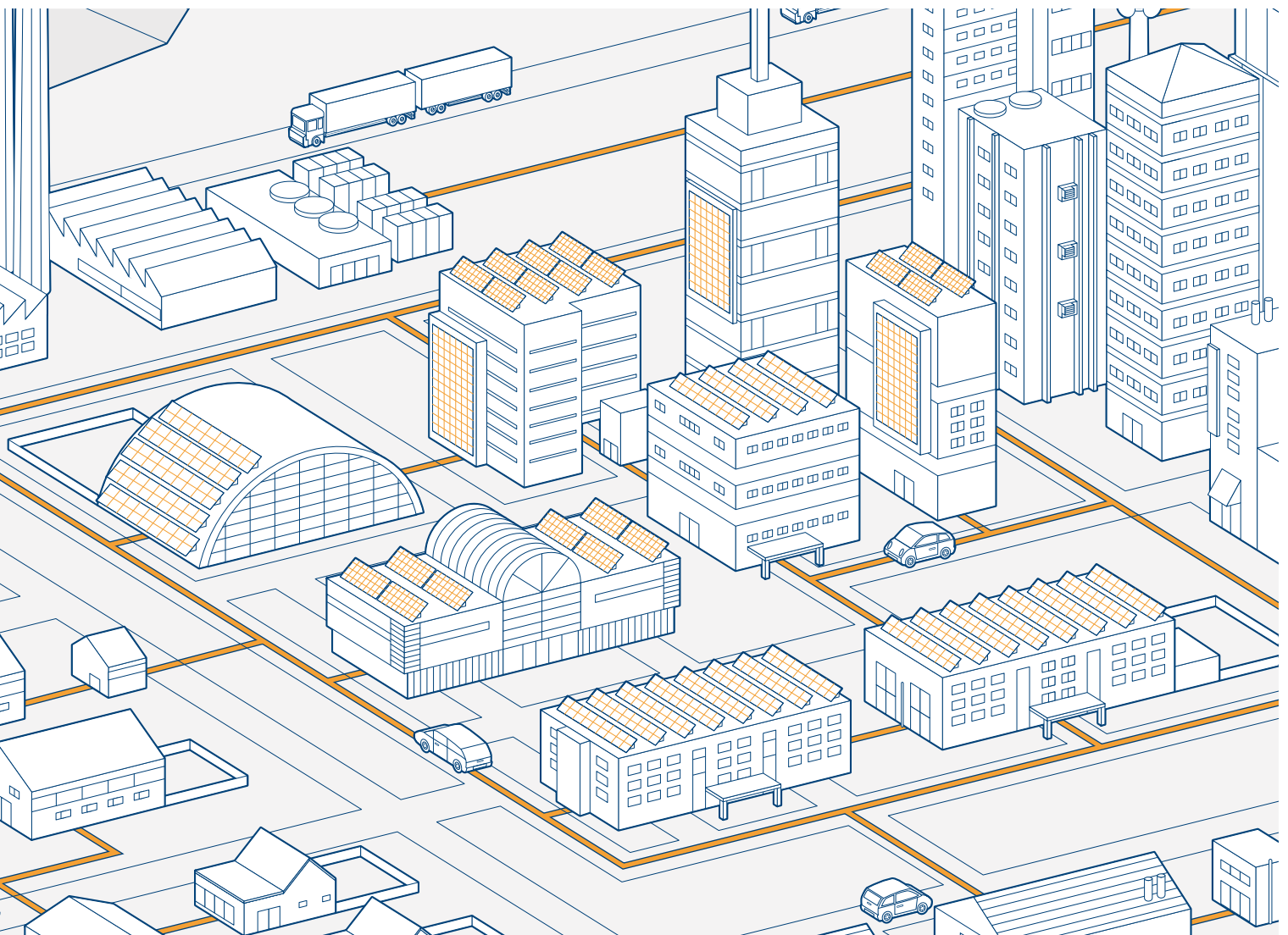
A photovoltaic system converts the sunlight into electrical energy captured by system modules. This process is becoming more and more effective thanks to technological evolution. In recent years the research has been working on the characteristics of photovoltaic modules and inverters to increase energy efficiency, but low-voltage components, are equally relevant to grant the continuity of service.

That is why ABB has focused on the development of solutions and devices, dedicated to designers and installers, aimed at building reliable photovoltaic installations, that are able to respond in the best way to the needs of energy production continuity.



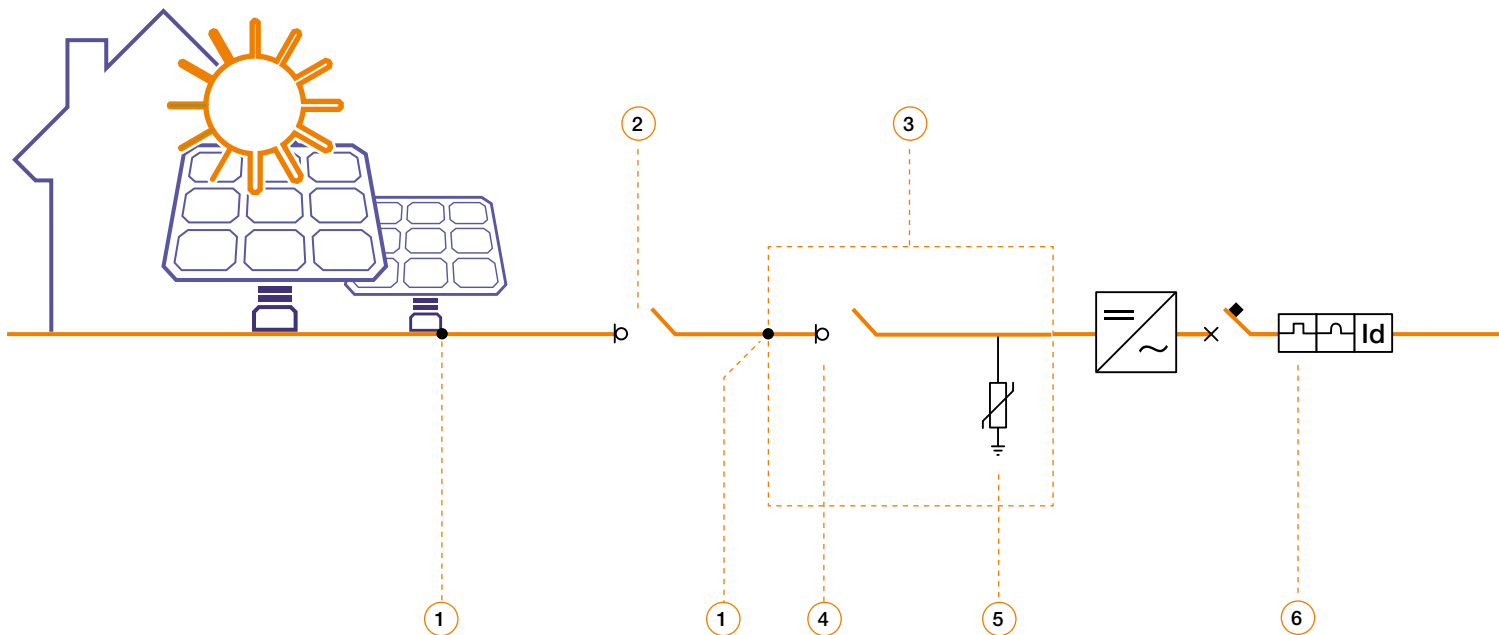
It is exactly what is commonly grouped under the acronym BOS (Balance of System, that is, “the rest of the system”) to play a key role in the operation of photovoltaic plant: the electro-mechanical equipment for connection, protection, control, disconnection and the cables provide adequate protection to persons and goods associated with the installation, but above all they ensure the actual production of energy. Every single component of a photovoltaic system must maintain its operating characteristics for the entire life cycle. Compared to a standard electrical system, the producer is responsible for ensuring that its products are reliable in the long term, to allow the proper economic return on the investments made. ABB, always attentive to new market needs, has developed a comprehensive and reliable range of products for

photovoltaic applications to ensure that all installation needs are fulfilled, starting from the string on the DC side, to the point of connection to the AC network. String boxes, circuit breakers, switch-disconnectors, residual current circuit breakers, interface relays, energy meters, fuses and fuse disconnectors, surge arresters, consumer units and enclosures suitable for outdoor use: they are all components of our offer, specially designed for photovoltaic applications of all sizes. ABB, in fact, has developed a series of “plug & operate” solutions (finished, wired and certified switchboards) to meet the needs of every kind of system, from the single string in a residential facility to a large solar farm.



# Examples of photovoltaic applications

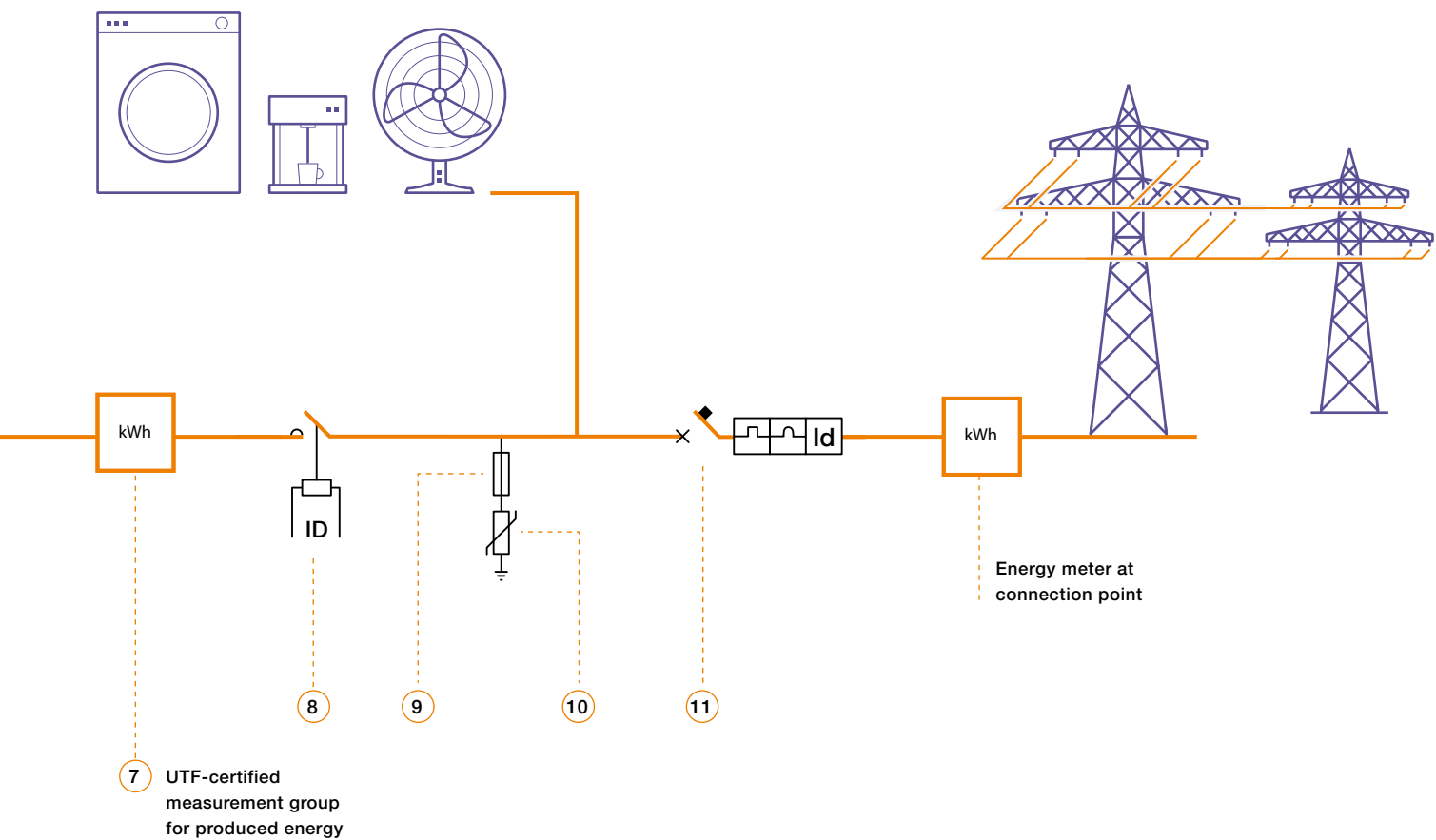
## Residential system $\leq 20$ kW LV



### Low-voltage products:

- 1 - Connectors: MC4-EVO2 PV
- 2 - PV Vault rapid shutdown
- 3 - **String boxes**
  - Switchboards: Gemini
  - Consumer units: Europa
  - Circuit breakers: S200 M UC Z, S800 PV-S
  - Fuse disconnectors: E 90 PV
  - Fuses: E 9F PV
  - Spring and screw terminal blocks: SNK PI
- 4 - Switch-disconnectors: OTDC, S800 PV-M
- 5 - Surge protection devices: OVR PV QS
- 6 - Residual current devices: F202B, F204B
- 7 - Energy meters: EQmeters and current transformers
- 8 - Contactors: AF Series
  - Grid-feeding monitoring relays: CM-UFD.Mxx
  - Power supplies: CP-x
- 9 - Fuse disconnectors: E 90
- 10 - Surge protective devices: OVR T1 / T1-T2 / T2 QS
- 11 - Residual current circuit breakers: DS202C

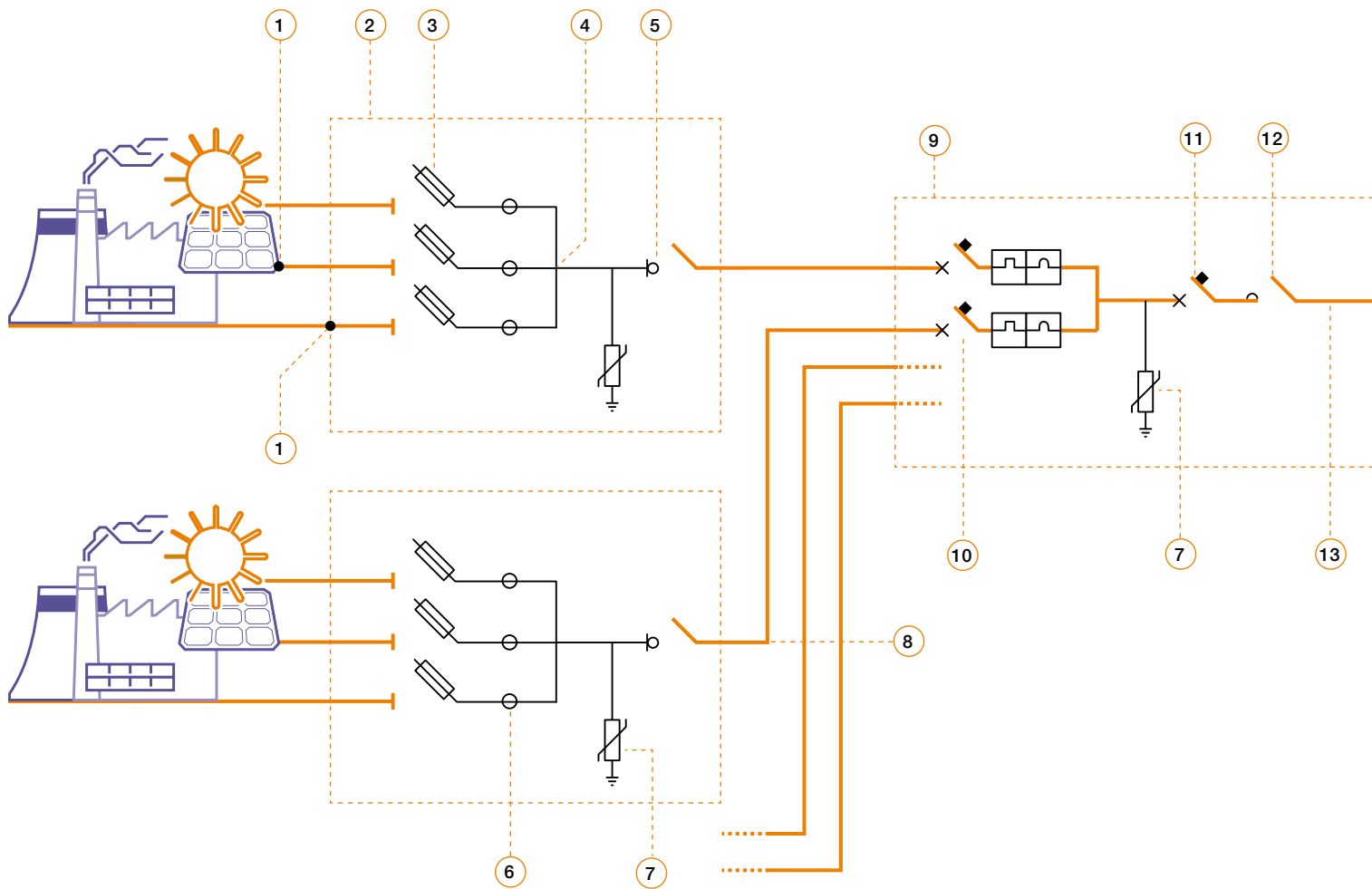






# Examples of photovoltaic applications

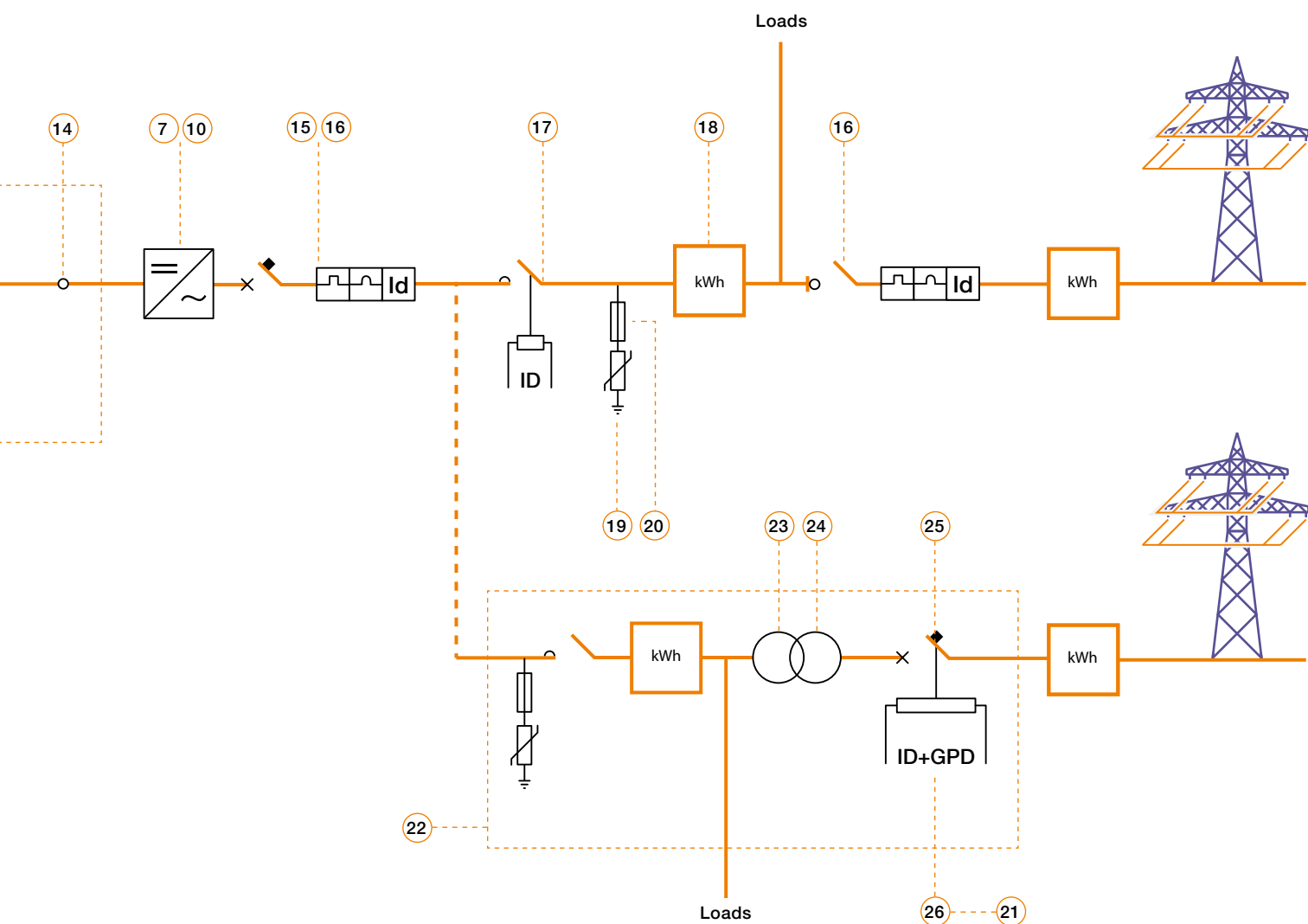
## Commercial system 20 - 1000 kW LV/MV



### Low-voltage products:

- |  |   |
|--|---|
| 1 - Connectors: MC4-EVO2 PV                          | 8 - String monitoring controller                        |
| 2 - <b>String combiners 1000 VDC</b>                 | 9 - Recombiner  |
| Switchboards: Gemini; Consumer units: Europa, Gemini | 10 - Miniature circuit breakers: S200 M UC Z, S800 PV-S |
| 3 - Fuse disconnectors: E 90 PV; Fuses: E 9F PV      | 11 - Switch-disconnectors: Tmax PV, OTDC series         |
| 4 - Distribution blocks: DBL                         | 12 - Contactors: GAF Series + IOR Series rail contactor |
| 5 - Switch-disconnectors: OTDC; S800 PV-M            | 13 - Insulation monitoring devices: CM-IWx              |
| 6 - Current measurement system: CMS                  | 14 - GFDI Application: S804U-PVS5                       |
| Power supplies: CP-x                                 | 15 - Residual current devices: F202B, F204B             |
| 7 - Surge protection devices: OVR PV QS              |   |





- 16 - Residual current blocks: DDA 200 B;  
Residual current circuit breakers: F200 type B;  
Miniature circuit breakers: S 200;  
Moulded case circuit breakers: Tmax XT, Tmax T
- 17 - Contactors: AF Contactor Series; Grid-feeding monitoring relays:  
CM-UFD.Mxx; Power supplies: CP-x
- 18 - Energy meters: EQ meters and current transformers
- 19 - Surge protective devices: OVR T1 / T1-T2 / T2 QS
- 20 - Fuse disconnect: E 90

- 21 - GSM telephone actuator: ATT

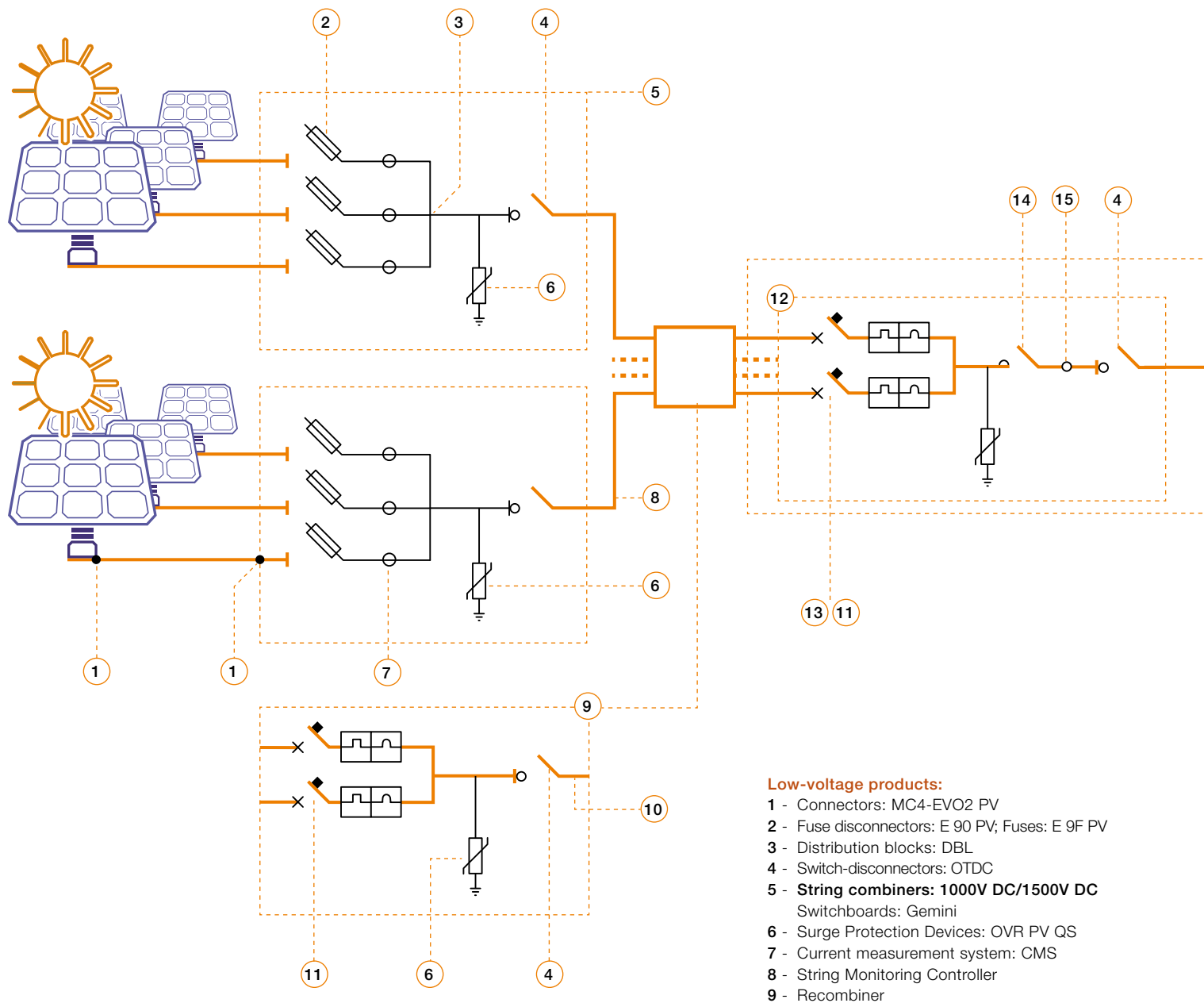
#### Medium-voltage products:

- 22 - Secondary substations
- 23 - Dry-type transformers
- 24 - Oil-immersed transformers
- 25 - Secondary switchboards
- 26 - Interface protection system: REF 542plus

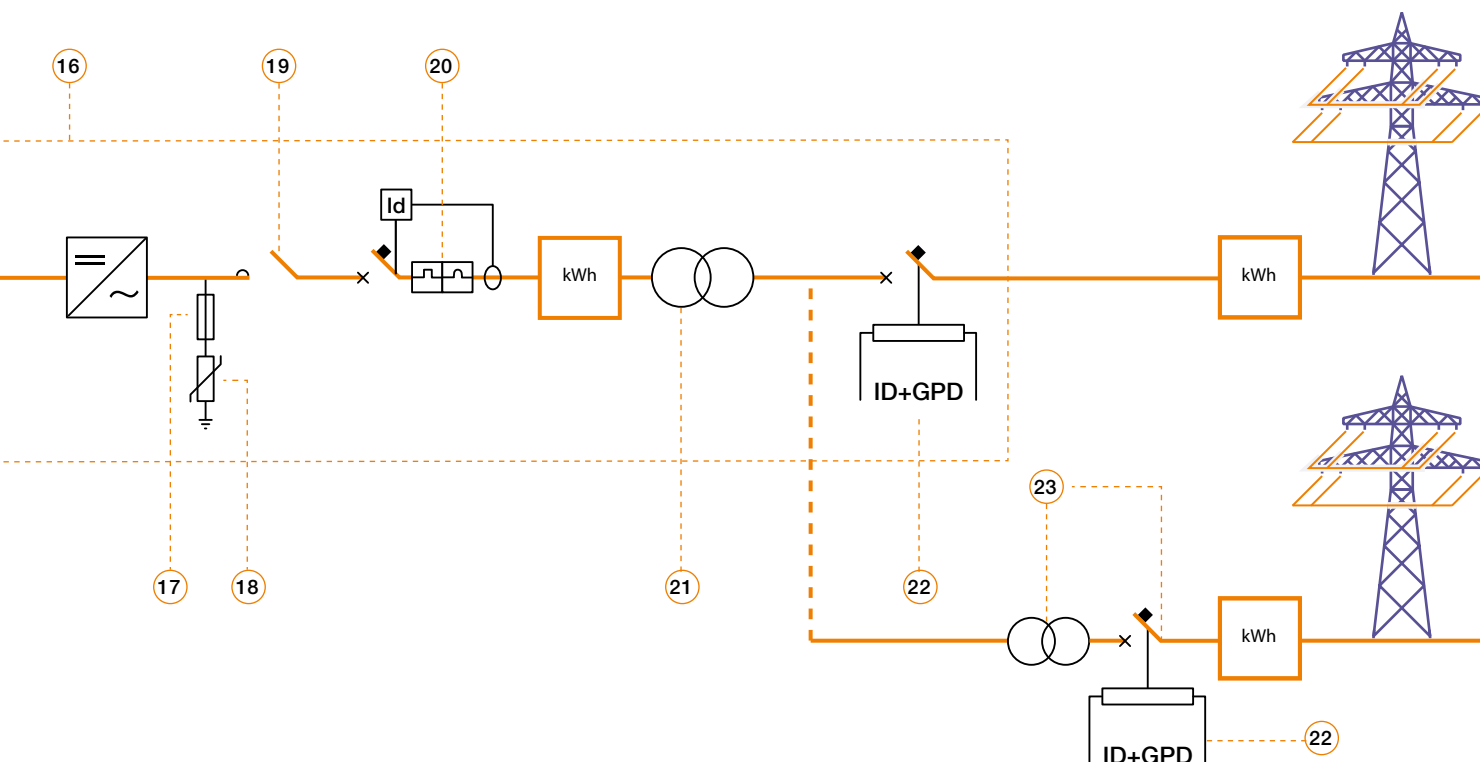


# Examples of photovoltaic applications

## Utility scale systems > 1000 kW MV/HV







- 10 - Current and voltage sensors: ES-VS Series
- 11 - Moulded Case Circuit Breakers: Tmax PV
- 12 - Switchboards: System pro E power
- 13 - Insulation monitoring devices: CM-IWx
- 14 - Contactors: GAF Series, IOR Series rail contactors
- 15 - GFDI Application: S804U-PVS5
- 16 - Megawatt station
- 17 - Fuse disconnectors: E 90
- 18 - Surge protection devices: OVR T1 / T1-T2 / T2 QS

- 19 - Contactors: AF Series
- 20 - Moulded case circuit breakers: Tmax XT, Tmax T
- Air circuit breakers: Emax 2

#### Medium-voltage products:

- 21 - Dry-type or oil filled transformers
- 22 - MV Switchgear + Interface protection system: REF 542plus
- 23 - Substation



# Direct Current

## Monitoring, control and protection of the photovoltaic system

The modules of a photovoltaic system are connected together through DC circuits setting up strings connected in turn to dedicated inputs inside the inverters. These circuits are powered by generators characterized by variable operating voltages, according to the initial sizing and the ambient temperature of the modules. Here the short circuit currents are close to the rated currents. Especially in case of large systems, DC circuits can be affected by lightning surges. Therefore, it is necessary to solve some problems such as overcurrent protection of the strings, disconnection and limitation of lightning surges.



### DC-side overcurrent protection

The DC circuits connect the modules to the inverter. These circuits may be subject to surges of different origin capable of damaging the modules and the input sections of the inverters themselves. To protect these circuits, it is necessary to use fuses or circuit breakers. Fuses are the normally used solution, as they are easy to install and have a low cost, but they must be replaced in case of failure. Circuit breakers, instead, include in a single device the protection and disconnect functions but have a higher initial cost. In case of intervention, the protection can be easily restored with no need for replacement.

### DC-side disconnection

By nature, the photovoltaic source stops only when the modules are shaded. To carry out maintenance and repair interventions safely, you must have a suitable disconnection system. This is because the voltages in DC circuits can reach very high values up to 1,500 V. With such high voltages, the disconnect must be executed through high-performance equipment that use special devices able to safely turn off the electric arc.

### DC-side overvoltage protection

Photovoltaic modules are generally installed in exposed locations. Often they cover large areas and are subject to overvoltage phenomena of atmospheric origin, such as lightening. The protection against these DC phenomena is important for small and medium size photovoltaic systems, but it becomes fundamental in the case of large solar farms. Protection must ensure that the voltage levels are maintained below the values of impulse withstand of modules and inverters: it is crucial, therefore, that the devices are distributed across the system, starting from the string boxes, the parallel string boxes and inside the inverter's input sections.

User connection	Low voltage				Medium voltage			
System connection to user network	Low voltage				Medium voltage			
System power (kWp)	≤ 10	≤ 30	≤ 100		≤ 400-600		≥ 400-600	
Inverter type	string				centralized			
	-	multi-string						
Number of strings	1	2	≤ 6	≤ 20	≤ 80-120		> 80-120	
E90 PV fuse disconnectors	■	■	■	■	■	■	■	■
E 9F PV fuses	■	■	■	■	■	■	■	■
S204 M UC Z miniature circuit breakers	■	■	■	■	■	■	■	■
S800 PV-S miniature circuit breakers	■	■	■	■	■	■	■	■
S800 PV-M switch-disconnectors	■	■	■	■	■	■	■	■
S802 PV-M-H switch-disconnectors	■	■	■	■	■	■	■	■
S804 PV-S5 ground fault Detector interrupter						■	■	■
OT-M switch-disconnectors	■	■	■					
OTDC switch-disconnectors	■	■	■	■	■	■	■	■
Tmax PV switch-disconnectors				■	■	■	■	■
GA contactors	■	■	■					
GAF contactors				■	■	■	■	■
OVR PV surge protection devices	■	■	■	■	■	■	■	■
ISL-A insulation monitoring devices	■	■	■					
CM-IWN insulation monitoring devices				■	■	■	■	■
CMS current measuring system			■	■	■	■	■	■
ES-VS series current sensors				■	■	■	■	■
Release for fire brigade	■	■	■	■	■	■	■	■
MC4-EV02 PV connectors	■	■	■	■	■	■	■	■
SNK PI-spring and screw terminal blocks	■	■	■	■	■	■	■	■
DBL distribution blocks			■	■	■	■	■	■

### Isolation monitoring

DC circuits in such high voltages represent an obvious problem for the of protection against indirect contacts. Modules and cables are protected by a double isolation from the ground with an IT system. In this way a first earth fault causes no disruption; in the case of a second problem, however, the overcurrent protection devices are triggered. For this reason it is essential that the first failure is appropriately detected and reported, to allow a maintenance intervention before a second failure causes a disruption of the service.

### Monitoring

The expected productivity of a photovoltaic system depends not only on the performance of the solar radiation; in fact, it is important to ensure the correct operation of all system's components. If the system is large (consisting of over 100 photovoltaic modules), there is a high risk that a malfunction or failure will reduce or undermine its proper functioning. It becomes important, therefore, to equip the photovoltaic installation with a system able to constantly measure the trend of the production of each field (and even of each single string), comparing the data with those of other fields (and other strings). In this way it will be easy to detect any abnormal situations that require a maintenance check. The system essentially consists of a series of modules capable of measuring the string currents, by sending data to a AC500 cabin PLC and then process them and make them accessible through a data logger.

# Pre-assembled solutions

## The advantages of standardization

In a photovoltaic system, the modules are arranged in strings and fields depending on the type of inverter used, the total power and the technical characteristics of the modules. The connection of modules in series is made on the modules themselves, while the parallel connection of the strings is realized in the so-called “string boxes” that accommodate, along with the interconnection systems, also the overcurrent protection devices, disconnectors and surge protection devices. In medium and large sized systems, the string boxes form subsystems that can be standardized according to the number of strings, voltage and rated current.

ABB offers four different product ranges, each dedicated to specific installation conditions with typical configurations.

### String boxes

The installation of a photovoltaic system often occurs in complex logistic situations, critical from the environmental and time perspective. The availability of tested and certified pre-assembled components allows the installer to avoid unnecessary on site assembly, wiring and certification activities for the string boxes. String boxes enclose functions such as string protection, protection against overvoltage and disconnect, with components suitable for the string's various voltage levels and the number of connected strings.

### Multi-output string boxes

The development and the increasingly frequent adoption of multi-string inverters has made it necessary to reduce the costs and the space occupied by the string boxes, to bring together in a single switchboard the protective devices and disconnectors of multiple strings intended to be connected to a specific inverter input. Multi-string inverters resolve in an easy and cost-effective manner system conditions characterized by modules installed in different leaning and exposure positions or minimize the problems related to systematic shading of parts of the system.

### String boxes for monitoring

The string monitoring is an important function in running medium and large size installations, since it allows to improve the manufacturability and maintenance of the system. ABB offers a series of pre-wired string boxes for all installation conditions: they are equipped both with devices necessary for string protection, surge protection and disconnection, and with useful devices for string monitoring.

### Interface boxes

To improve installation logistics operations, ABB developed specific interface boxes in accordance to several local Standards. Also in this case the right choice allows to make available to the designer and the installer predefined solutions on the basis of the system power, equipped with general switch, fuseholder, interface relay, interface device, power supply system with energy storage, auxiliary contacts and control coil for the support device.



Description		String Protection	Surge Protection	Disconnecter	Monitoring	Enclosure Type	IP Rating
Product Type		E90 PV + E9F PV	OVR PV T2	OTDC	Optional		
1000V DC	1-2 String	-	■	■	-	Europa	IP65
	3 Strings	■	■	■	-	Europa	IP65
	4 Strings	■	■	■	-	Europa	IP65
	6 Strings	■	■	■	-	Gemini	IP66
	8 Strings	■	■	■	-	Gemini	IP66
	10 Strings	■	■	■	-	Gemini	IP66
	12 Strings	■	■	■	Yes	Gemini	IP66
	14 Strings	■	■	■	Yes	Gemini	IP66
	16 Strings	■	■	■	Yes	Gemini	IP66
	18 Strings	■	■	■	Yes	Gemini	IP66
	20 Strings	■	■	■	Yes	Gemini	IP66
	24 Strings	■	■	■	Yes	Gemini	IP66
	28 Strings	■	■	■	Yes	Gemini	IP66
	32 Strings	■	■	■	Yes	Gemini	IP66
Product Type		Fuse Holder + Fuse 1500VDC	OVR PV T2 1500VDC	OTDC 1500VDC	Optional		
1500V DC	12 Strings	■	■	■	Yes	Gemini	IP66
	14 Strings	■	■	■	Yes	Gemini	IP66
	16 Strings	■	■	■	Yes	Gemini	IP66
	18 Strings	■	■	■	Yes	Gemini	IP66
	20 Strings	■	■	■	Yes	Gemini	IP66
	24 Strings	■	■	■	Yes	Gemini	IP66
	28 Strings	■	■	■	Yes	Gemini	IP66
	32 Strings	■	■	■	Yes	Gemini	IP66

#### Multiple output String Boxes

Description	N. of Strings	String Protection	Surge Protection	Disconnecter	Monitoring	Enclosure Type	IP Rating
Product Type		E90 PV + E9F PV	OVR PV T2	OTDC	Optional		
1000V DC	2 in 2 out	■	■	■	-	Europa	IP 65
	4 in 2 out	■	■	■	-	Europa	IP 65
	6 in 2 out	■	■	■	-	Gemini	IP 66

# Alternating Current

## Guaranteed and monitored energy production

In a photovoltaic installation, the AC section has the dual role of connecting the system to the end user's electrical circuit and to the distribution network.

Its job, therefore, is to ensure proper transfer of the energy produced, while meeting the safety requirements prescribed by the applicable law.

ABB develops equipments designed for protection against indirect contacts and technologies dedicated to the interface system and to the exact monitoring and calculation of the energy produced. The installation, even in this case, must be protected against overvoltage relating to the inverter and the interface, which could cause damage or temporary interruptions of the energy production.

### Protection against AC-side indirect contacts

The AC circuits, which connect the inverter to the installation and the energy provider's network, are formed by a TT-type ground connection system in the case of small loads powered at low-voltage, while the medium-voltage systems with their own transformation cabin have a TN-S-type ground connection system.

In both situations it is necessary to use systems able to protect people from indirect contacts that may occur due to the breakdown of isolation in any part of the installation. This function is normally carried out by a residual current circuit breaker which must be selected based on the characteristics of the inverter and the possibility that in case of failure it can generate direct or pulse leakage currents. As a consequence of this feature, it may be necessary the adoption of a B, A or AC-type residual current circuit breaker.

### AC-side overcurrent protection

In the system section connected to the distribution network, which constitutes the AC current side, despite the voltage values are significantly lower than those affecting the DC side, you may encounter very high values of operating and short circuit current. The protective devices must therefore be selected so as to ensure the proper protection of the conductors and the connected devices. As the system power increases, in fact, the compactness, the temperature derating, the availability of accessories and the calibration range of the protective devices become more important.

### AC-side overvoltage protection

Inverters are electronic devices that have voltage impulse withstand normally lower than that of normal electrical appliances. Precisely because they are more sensitive to surges that can damage them and prevent their proper operation, special attention must be paid when selecting the protective equipment. Once evaluated the type of protection, depending on the greater or lower chance that the system is exposed to the risk of direct lightning strikes, you can determine whether it is necessary to install lightning current arresters; furthermore you can decide how to structure the protection system and choose and deploy the installation surge arresters across the system.

### IP interface protection

The interface protection ensures that the photovoltaic system is connected in parallel to the network using voltage and frequency parameters complying with the limits prescribed by the regulations. The proper functioning of the protection relay ensures the safety of equipment and personnel who operate on the distribution network. The reliability of the relay, its pre-configuration and the simplicity of the tests are the most important features to be considered in choosing the most suitable interface protection. Fundamental is the choice of a protection interface in conformity with regulations, applicable to the specific system type, also depending on the country of installation.



User connection	Low-voltage				Medium-voltage			
System connection to user network	Low-voltage					Medium-voltage		
System power (kWp)	≤ 10		≤ 30	≤ 100	≤ 400-600		≥ 400-600	
Inverter type	string				centralized			
	-	multi-string						
Number of strings	1	2	≤ 6	≤ 20	≤ 80-120		> 80-120	
S200 miniature circuit breakers	■	■	■	■	■			
S200 miniature circuit breakers	■	■	■	■	■			
F200 residual current circuit breakers	■	■	■	■	■			
DDA200 residual current blocks	■	■	■	■	■			
DS202C residual current circuit breakers	■	■						
Tmax moulded case circuit breakers				■	■	■	■	■
Emax 2 air circuit breakers						■	■	■
GAF contactors	■	■	■	■	■	■	■	■
EK contactors					■	■	■	■
OT switch-disconnectors	■	■	■	■	■	■	■	■
OVR surge protection devices	■	■	■	■	■	■	■	■
CM-UFD.Mxx monitoring relays		■	■	■				
CP power supplies			■	■	■	■	■	■
CP-B energy storage units	■	■	■	■				
Interface switchboards	■	■	■	■				
EQ energy meters	■	■	■	■	■	■		
CT current transformers	■	■	■	■	■	■		
ISL insulation monitoring devices	■	■	■	■	■	■	■	■
ATT GSM telephone actuator	■	■	■	■	■	■	■	■
SNK PI-spring and screw terminal blocks	■	■	■	■	■	■	■	■

### DDI Interface Unit

The interface device is a remote control device intended to connect the production facility to the distribution network on the input of the interface protection.

Normally this function is performed by a contactor, but in some cases a motor-operated circuit breaker can be useful.

The selected device must be able to withstand the system's operating current (with AC1 or AC3 switching characteristics according to the applicable regulation) and be protected by the devices installed in the circuit.

### Energy Measurement

Measuring the energy produced by the various sections of a photovoltaic system and by various user circuits is critical for the proper energy management of the system. Evaluating the energy generation differences in the various photovoltaic fields, comparing the data with the different exposure and shading conditions, allows the optimization of the electrical production and a better management of the maintenance activities. Versatile measuring devices that are easy to configure and to connect to the network allow to implement measurement and control systems in a simple and effective manner.

# Contacts

[www.abb.com/solar](http://www.abb.com/solar)  
[www.abb.com](http://www.abb.com)

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