



Inverter and Monitoring System

Thai German Solar Training Week 8 - 10.10.2014

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9.10.2014

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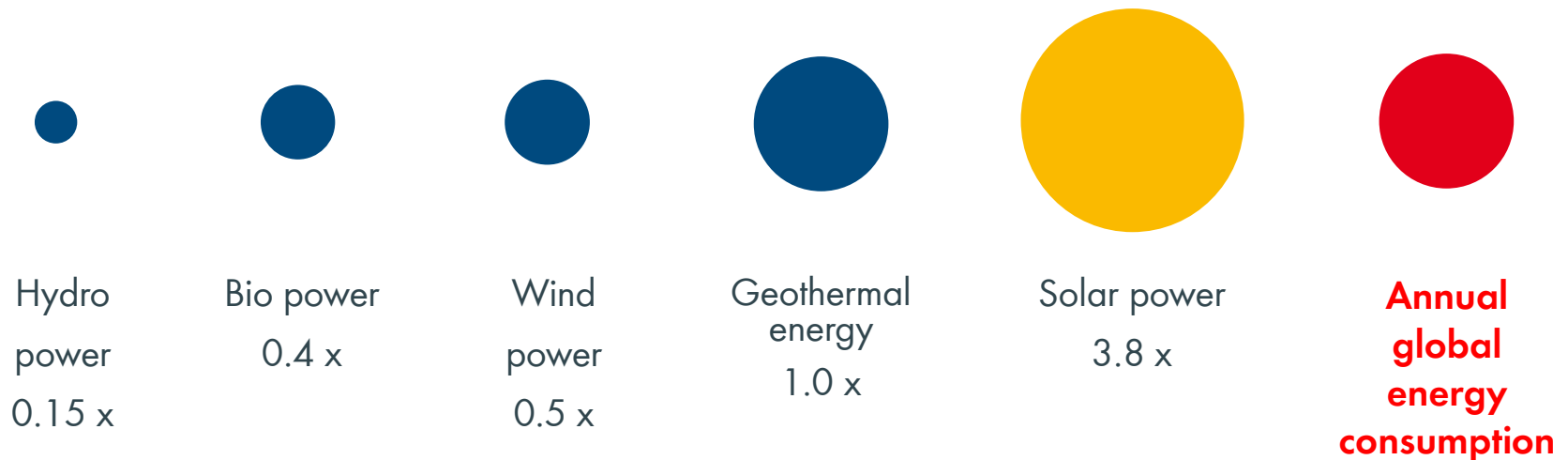
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Why renewable energies?

- Fossil fuels are limited (50 to 200 more years) and discharge emissions harmful to the climate
- Renewable energies provide unlimited resources while avoiding harmful emissions
- Solar energy alone could cover the world's energy demand 3.8 times



1

Inverter topologies

2

Inverter features

3

Planning and design concept

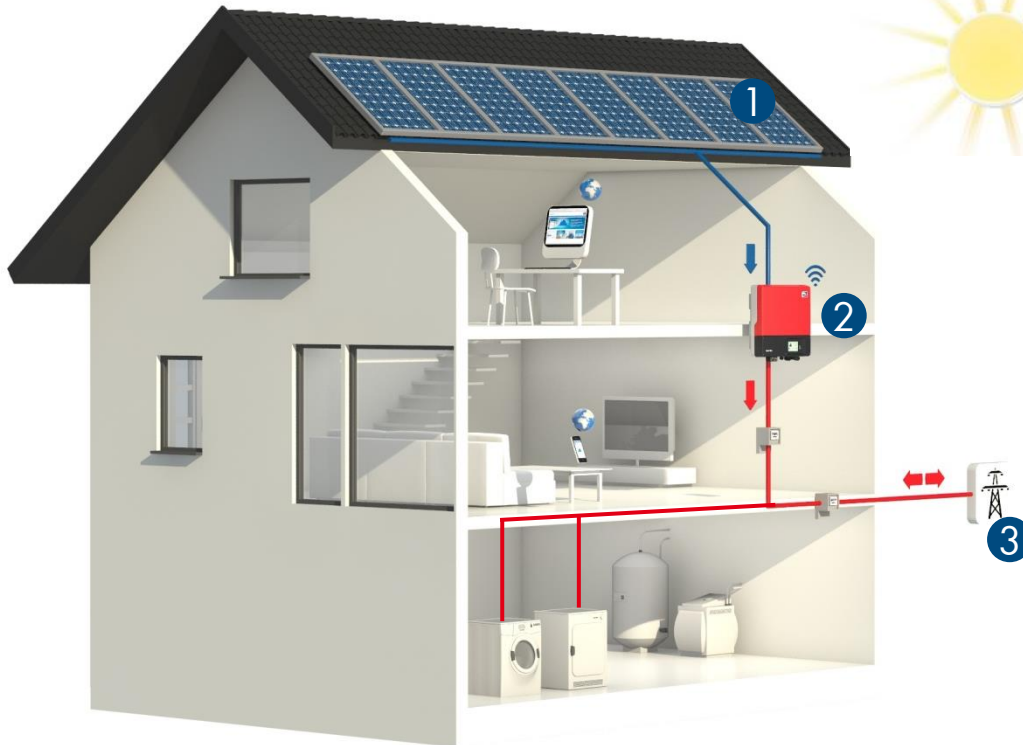
4

Inverter installation

5

Inverter monitoring

Overview On – Grid Photovoltaic System



1 **PV generator** converts sun power into direct current

2 **SMA Inverter** converts direct current into alternating current

3 **Utility Grid** provide alternating voltage

Overview On – Grid Photovoltaic System

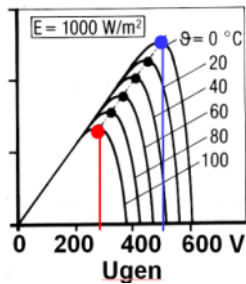


Additional tasks of the inverter

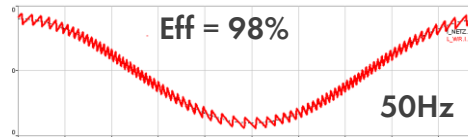
- > Maximum Power Point (MPP)-Tracking
- > System control and monitoring
- > Grid monitoring and services

PV inverter need to have – Functions and Requirements

MPP-Tracking



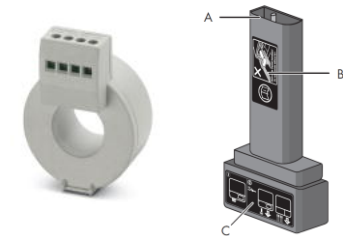
Inverting DC to AC



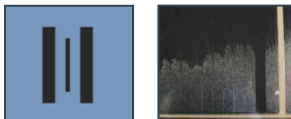
International compatibility
(country configuration, certificates)



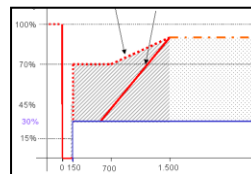
Protective features
(RCMU, R_{iso}, DC-switch)



Galvanic Isolation
(for TF modules)



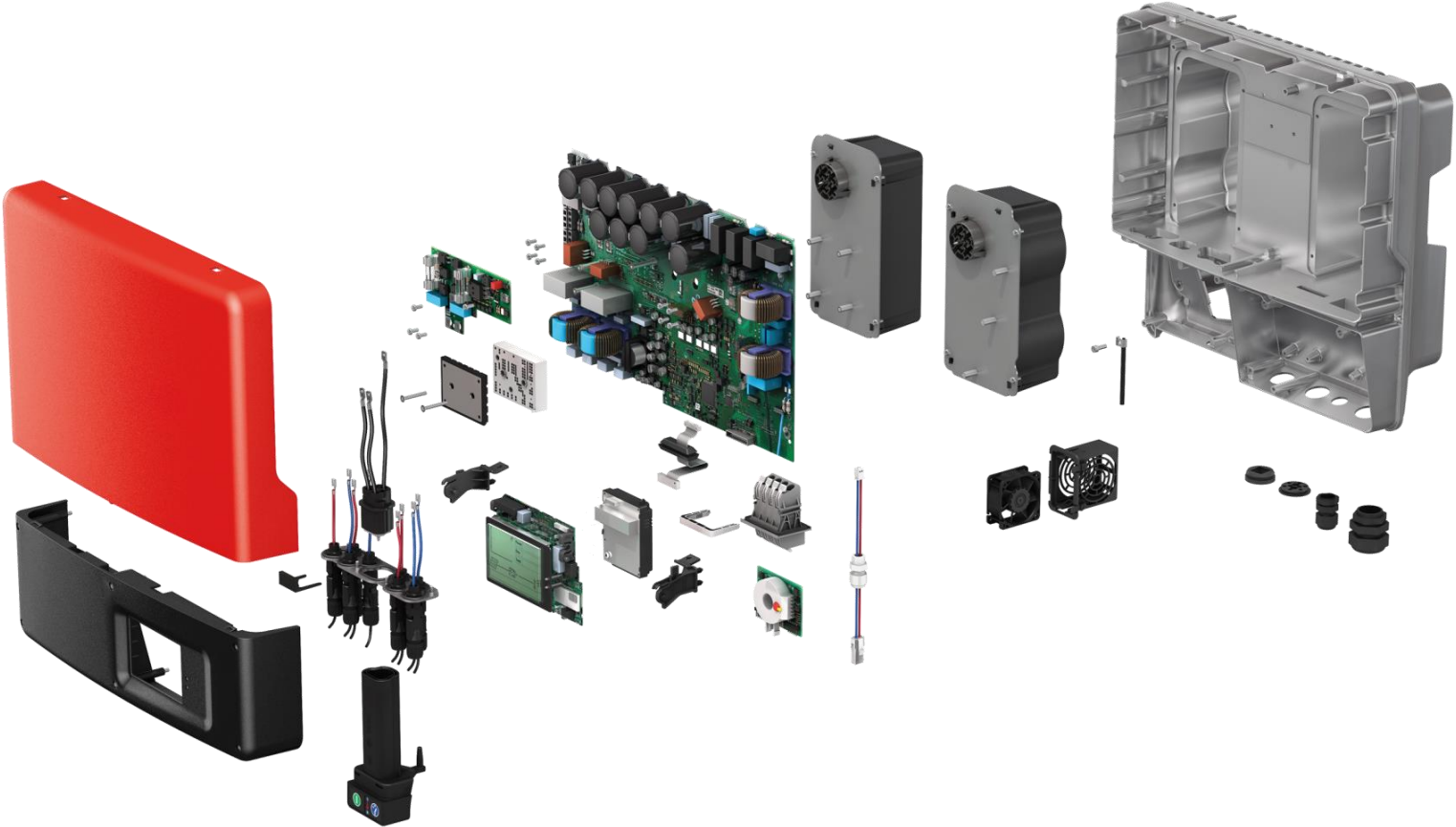
Grid monitoring and
management



Plant performance
monitoring



Inverter topologies with or without transformer



Topologies – Inverter with transformers

> Inverter with LF transformer (50Hz)

- Galvanic isolation
- Worldwide application
- Can be used both with crystalline cells and thin film modules
- Suitable for PV array grounding

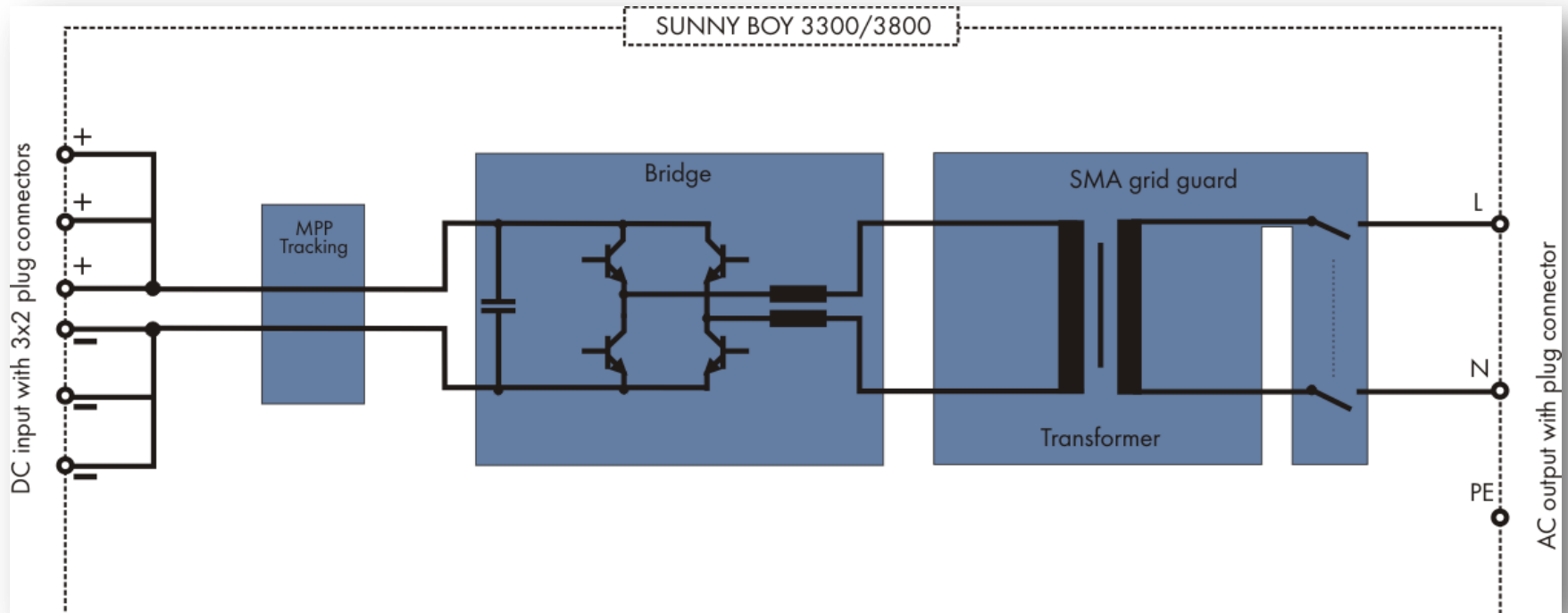


> Inverter with HF transformer (48kHz)

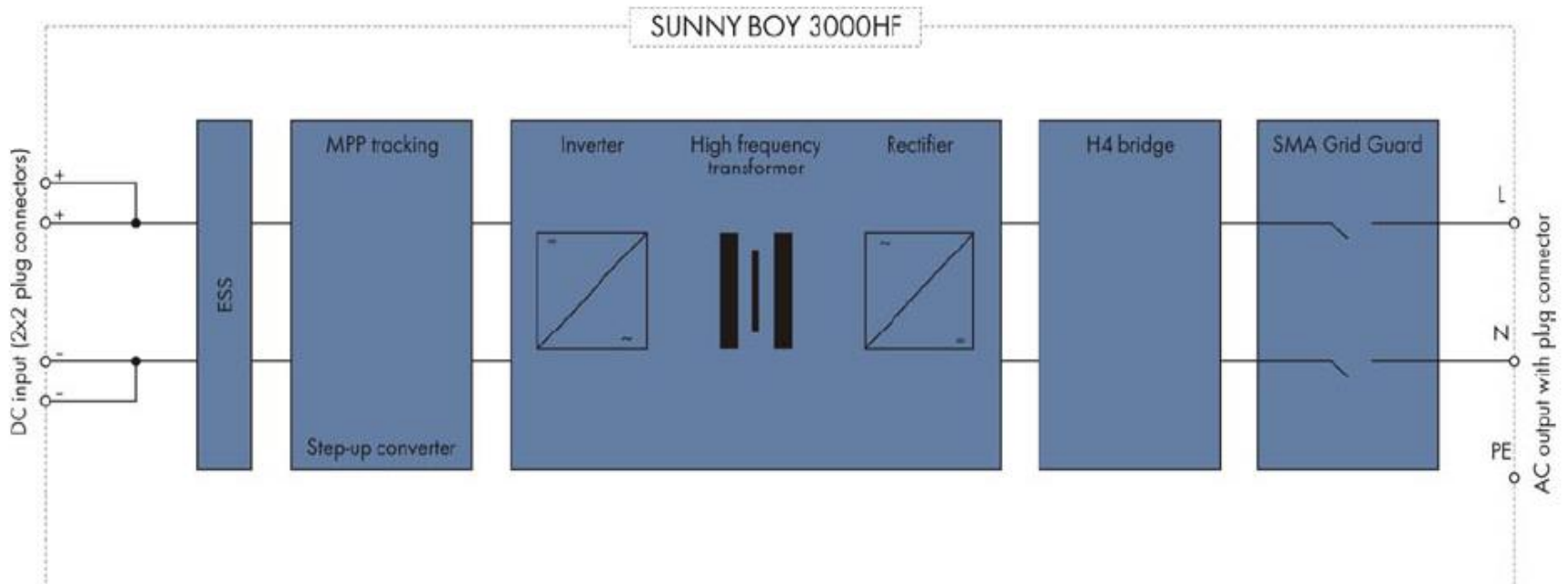
- Galvanic isolation
- Worldwide application
- Reduced weight and dimensions (compared with 50Hz transformers)



String inverter with transformer : Inverter with LF transformer (50Hz)



String inverter with transformer : Inverter with HF transformer (48kHz)

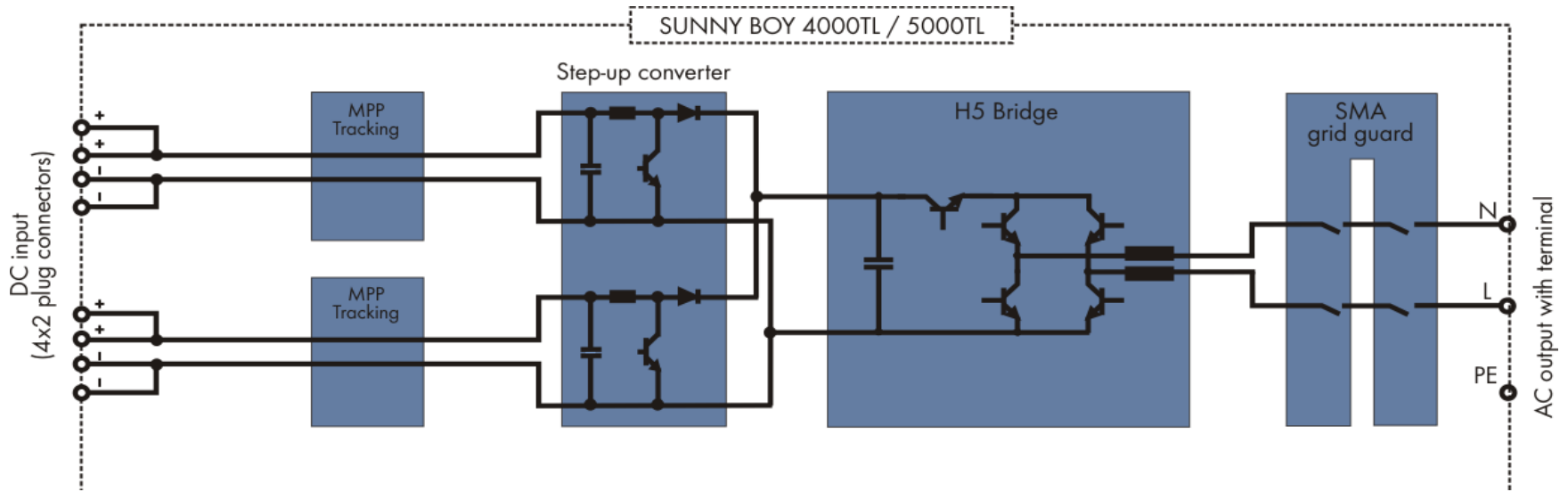


Topologies – Inverter without transformers

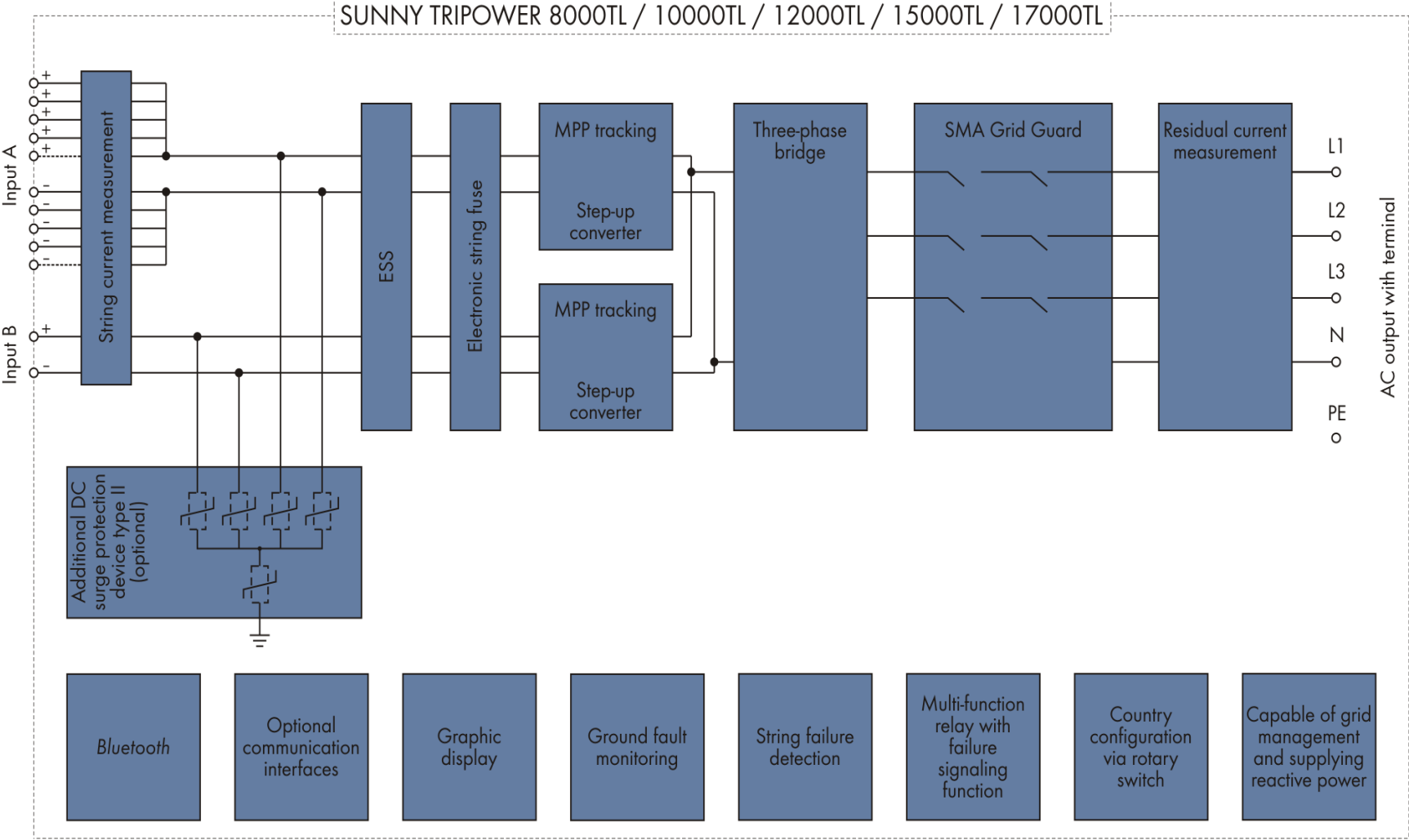
- > Inverter without transformer (**PV array grounding not allowed!**)
 - Highest efficiency, reduced weight
 - Suitable with crystalline cells, not recommended with thin film modules



Multistring inverter without transformer



Three-phase inverter without transformer



Inverter features need to have

- > High efficiency
- > Reliability
- > Protection feature
- > Grid monitoring
- > Grid management
- > Easy monitor and control
- > Easy installation
- > Country certificate



Efficiency

> High system efficiency

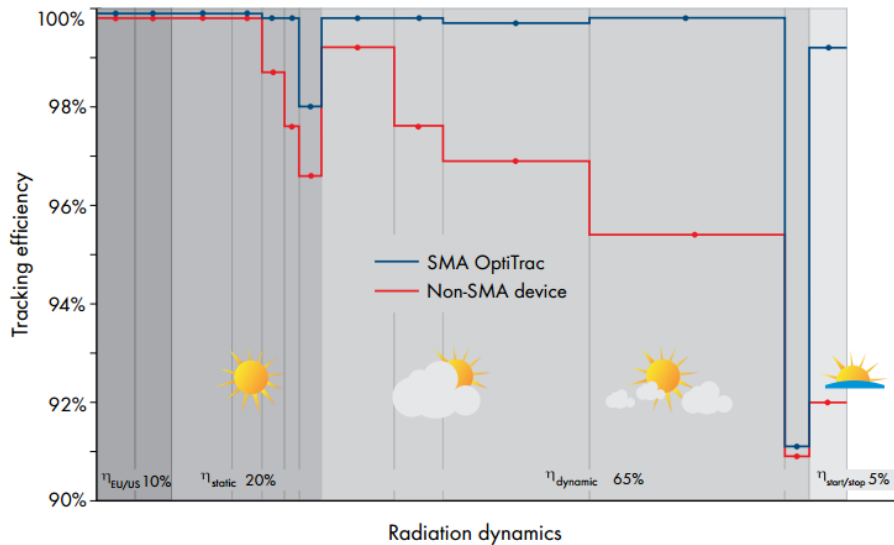
- Quality of the electronic components (H5 Technology)
- Fast finding and holding of the Maximum Power Point (MPP) (OptiTrac, OptiTrac Global Peak)
- High efficiency also during partial load operation

$$\eta = \frac{\text{Output power}}{\text{Input power}} = \frac{P_{AC}}{P_{DC}}$$

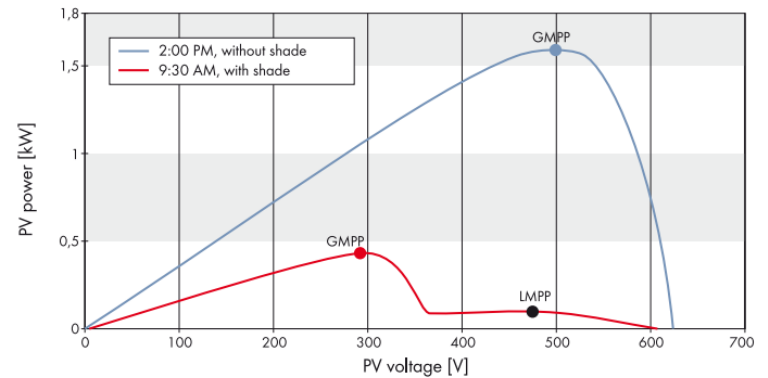
Efficiency

> Maximum Power Point Tracking Technology

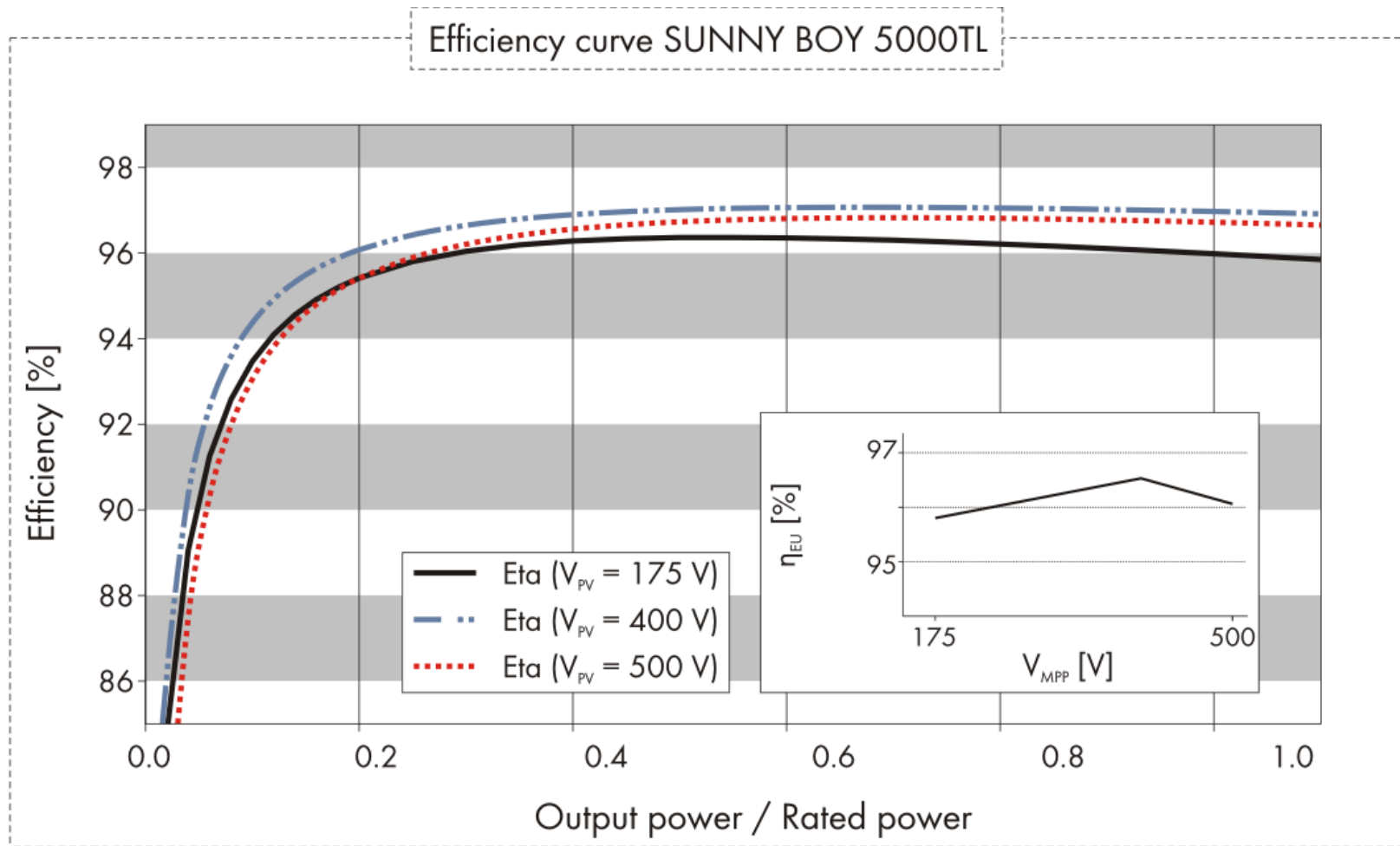
OptiTrac



OptiTrac Global Peak



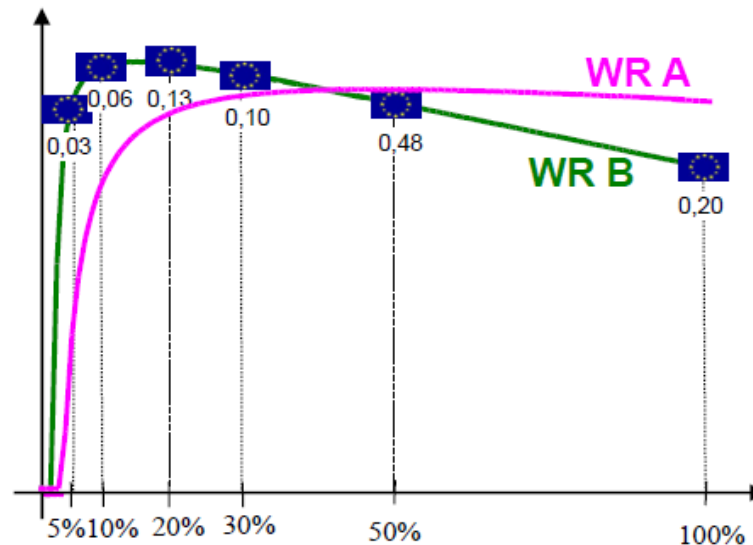
Efficiency Curve



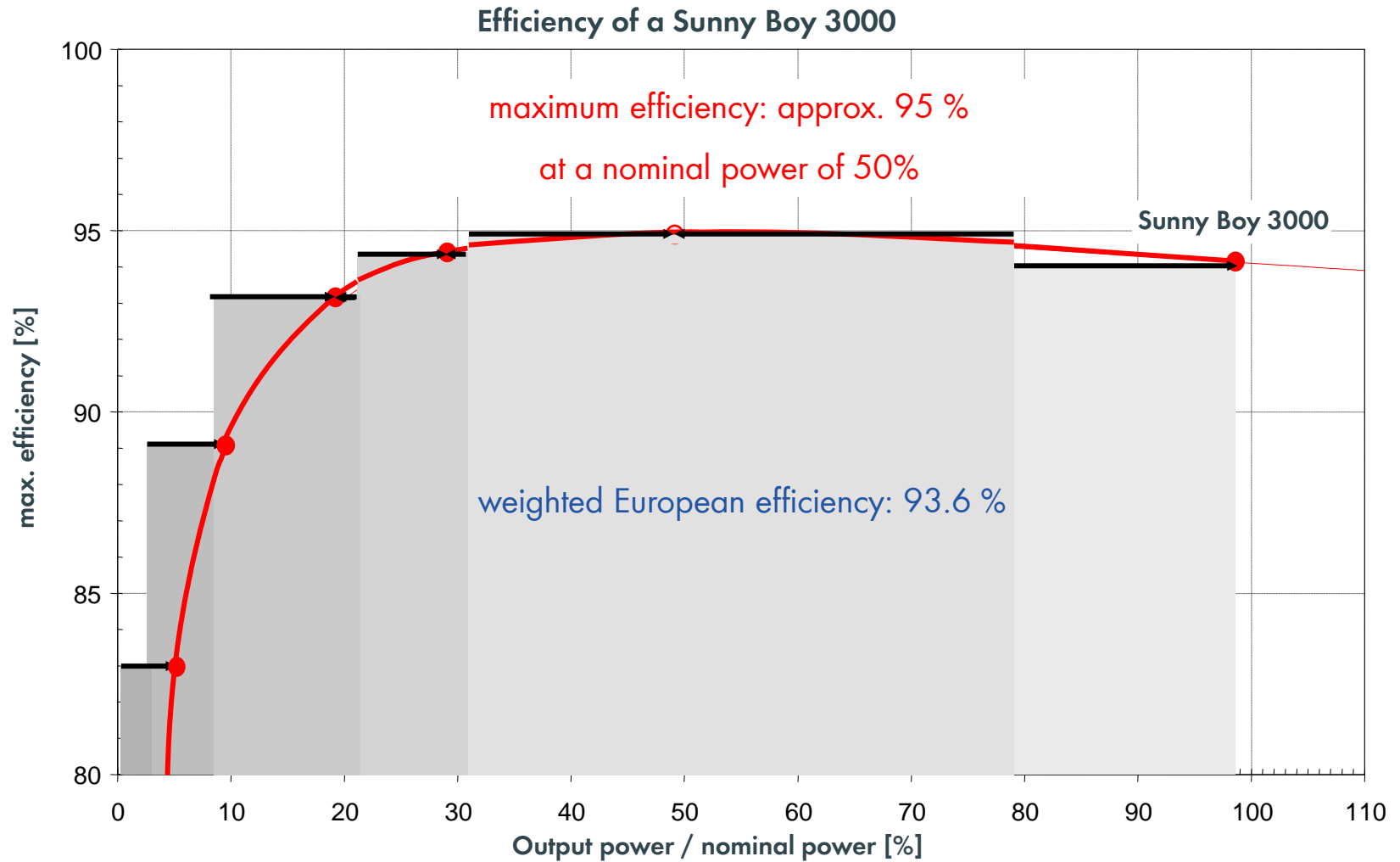
European Efficiency

- > The weighted European efficiency assesses the partial load behavior for PV plants in Central Europe
- > This value is used to compare similar devices

$$\eta_{\text{euro}} = 0,03 \times \eta_{5\% P_n} + 0,06 \times \eta_{10\% P_n} + 0,13 \times \eta_{20\% P_n} + 0,1 \times \eta_{30\% P_n} + 0,48 \times \eta_{50\% P_n} + 0,2 \times \eta_{100\% P_n}$$



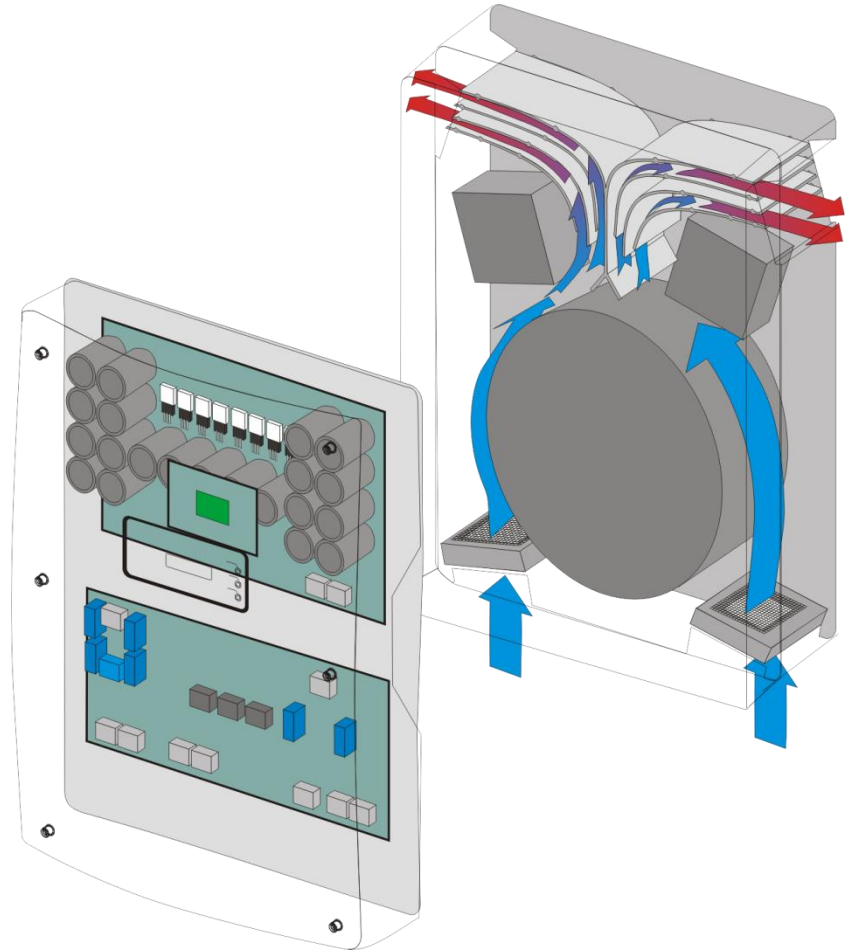
Efficiency in partial load



Reliability

> Maximum reliability

- Intelligence cooling concept
avoid temperature derating
- High protection rating, e.g. IP 65
due to robust enclosure
- Large temperature range
(-25°C to +60°C)



Reliability

> Maximum reliability

- Intelligence cooling concept
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- Large temperature range
(-25°C to +60°C)



Protection technology

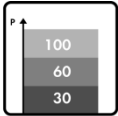
- > Input-side disconnection device (Electronic Solar Switch – ESS)
- > All-pole sensitive residual current monitoring unit (Transformerless inverter)
- > Ground fault monitoring
- > DC surge arrester Type III (Varistors)
- > Grid monitoring (SMA Grid Guard)

Additional protection in Sunny Tripower (STP-10)

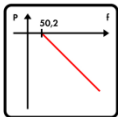
- > Electronic string fuse
- > Self-learning string failure detection
- > String current measurement



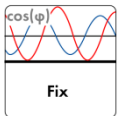
Grid Management



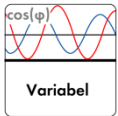
Power limitation as per EEG §6 / Grid safety management



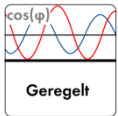
Frequency-dependent control of active power



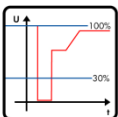
Fixed definition of the reactive power by the utility operator



Definition of a dynamic set point of the reactive power by the utility operator



Control of the reactive power over a characteristic curve



Monitored dynamic grid support: LVRT (Low Voltage Ride Through)

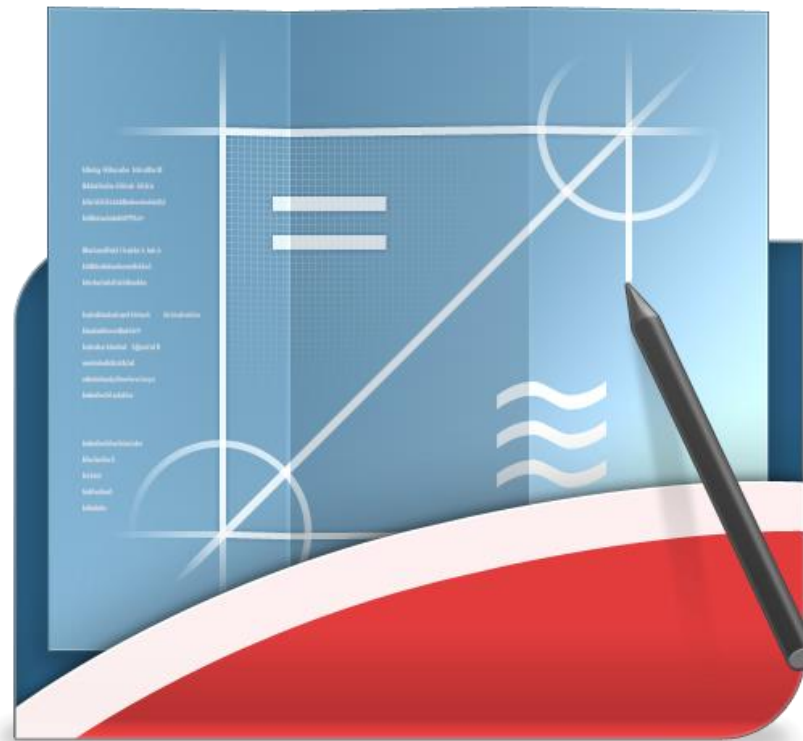
Monitor and control

> Easy functional control

- Detailed plant monitoring
- Easy fault diagnosis

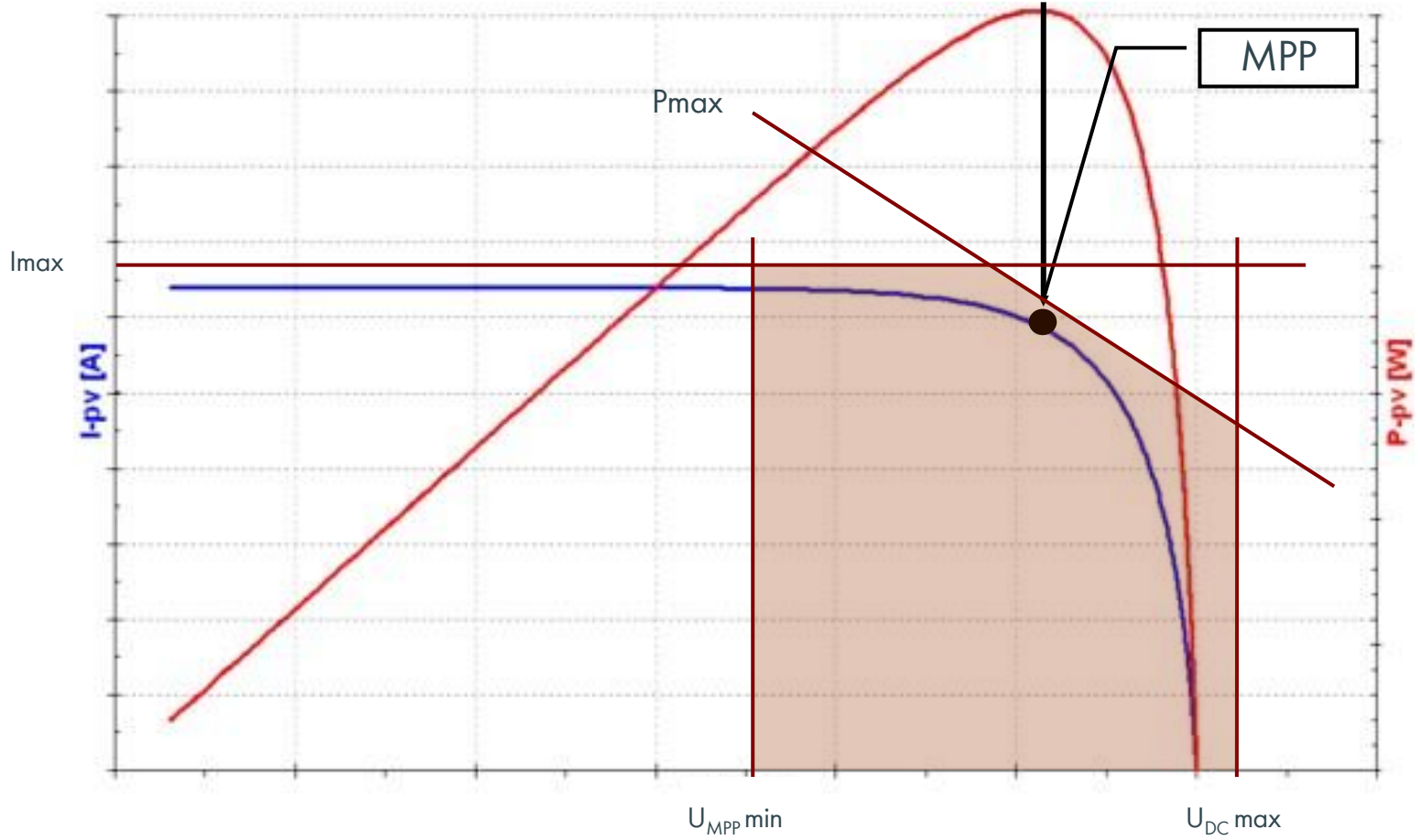


Planning and design concept



www.sunnydesignweb.com

Adjustment of PV Array and Inverter

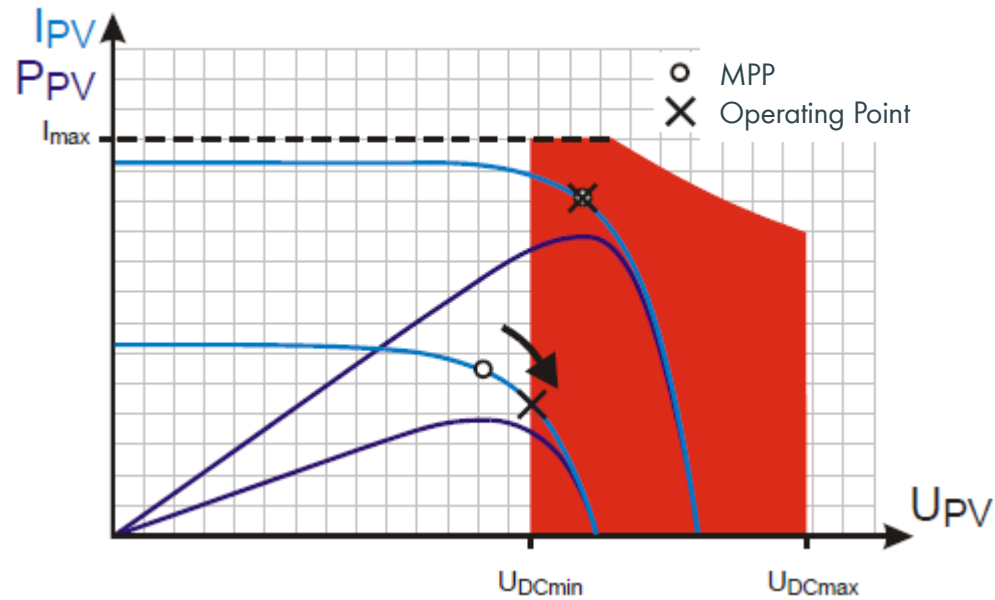


Inverter Specification

Technical data	Sunny Boy 3600TL
Input (DC)	
Max. DC power (@ $\cos \phi = 1$)	3880 W
Max. input voltage	750 V
MPP voltage range / rated input voltage	175 V ... 500 V / 400 V
Min. input voltage / initial input voltage	125 V / 150 V
Max. input current input A / input B	15 A / 15 A
Max. input current per string input A / input B	15 A / 15 A
Number of independent MPP inputs / strings per MPP input	2 / A:2; B:2

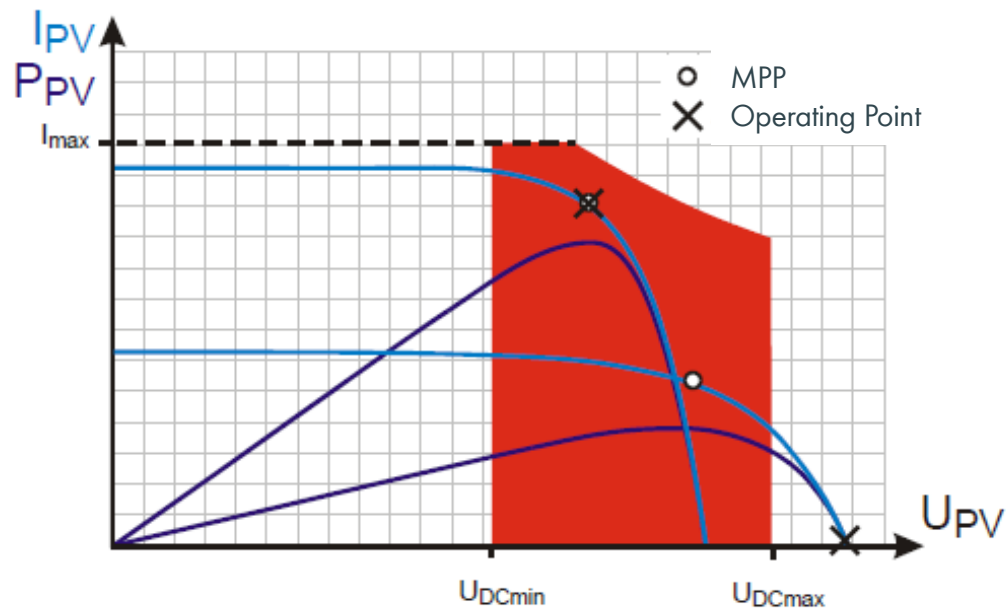
Lowest Operating Voltage

- > In the example, the MPP voltage of the PV array is lower than the lowest possible inverter input voltage



Highest Operating Voltage

- > The highest PV-array operating voltage (open-circuit voltage) is achieved at the lowest PV cell temperature
- > In the example, the open-circuit voltage of the PV array is higher than the maximum inverter input voltage → **inverter damage may occur!**



Plant design

- > Ex. threshold values for the voltage dimensioning:
 - > V_{MPP} (70°C)
 - > MPP voltage at 1000W/m²
 - > Cell temperature of +70°C
 - > V_{OC} (-10°C)
 - > Open circuit voltage at 1000W/m²
 - > Cell temperature of -10°C
- > Avoid shading of solar cells!
 - > in case of unavoidable shading — > limit the strings concerned!
- > Optimize orientation, if possible!

Optimized Operation of Partly Shaded PV Plants

> The most important recommended proceedings are:

- Group generator parts with similar irradiation
- No parallel connection of strings; but use a separate MPP tracker for each string (multi-string technology)

Inverter installation



> **Please follow the instructions of installation manual !**

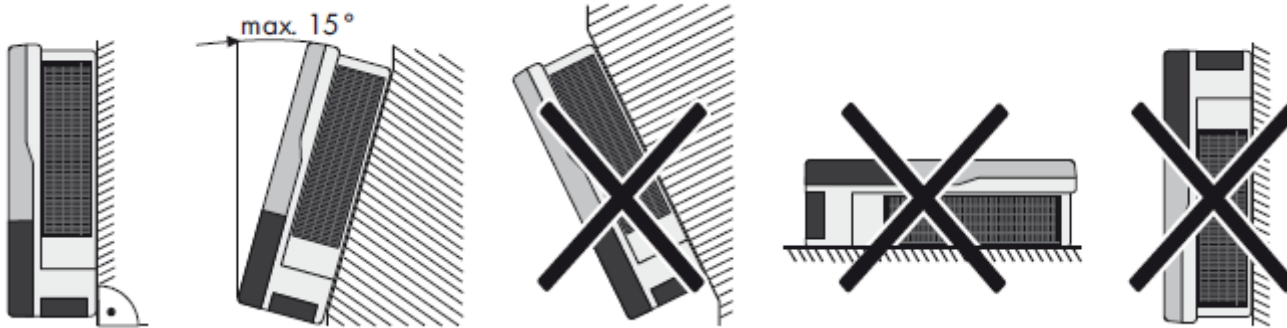
Inverter installation

- > Mounting
- > Remove the enclosure lid
- > Connection to the Electricity Grid (AC)
- > Connecting the PV Array (DC)
- > Close the enclosure lid
- > Commissioning

Inverter Mounting – STP 15000/20000TLEE-10

> Mounting Condition

- mounting on solid surface non-flammable surface only
- mounting location

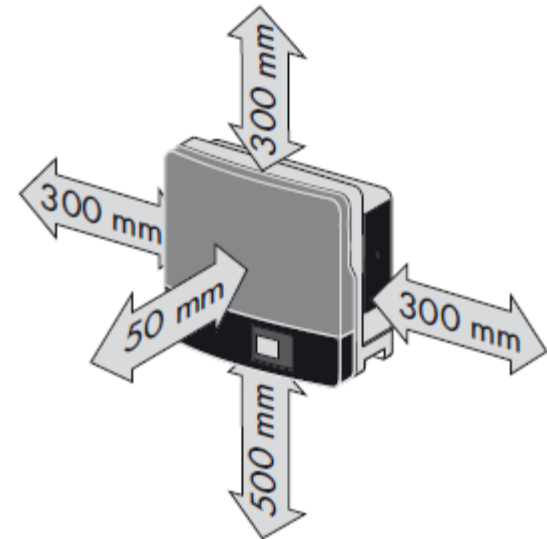


- ambient temperature range between -25°C and $+60^\circ\text{C}$

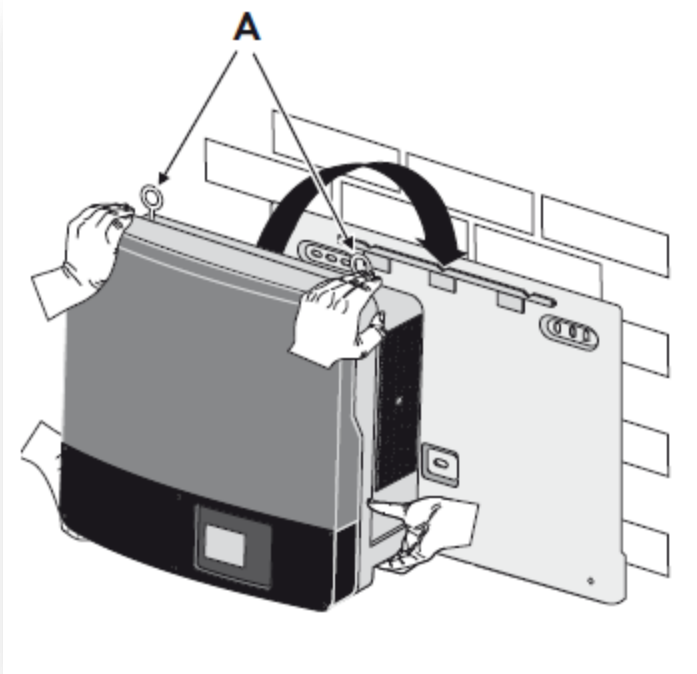
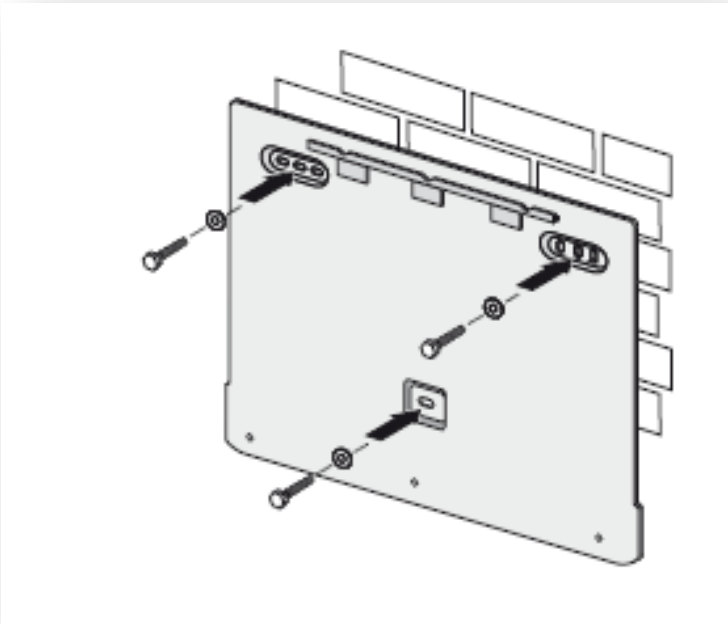
Inverter Mounting – STP 15000/20000TLEE-10

> Mounting Condition

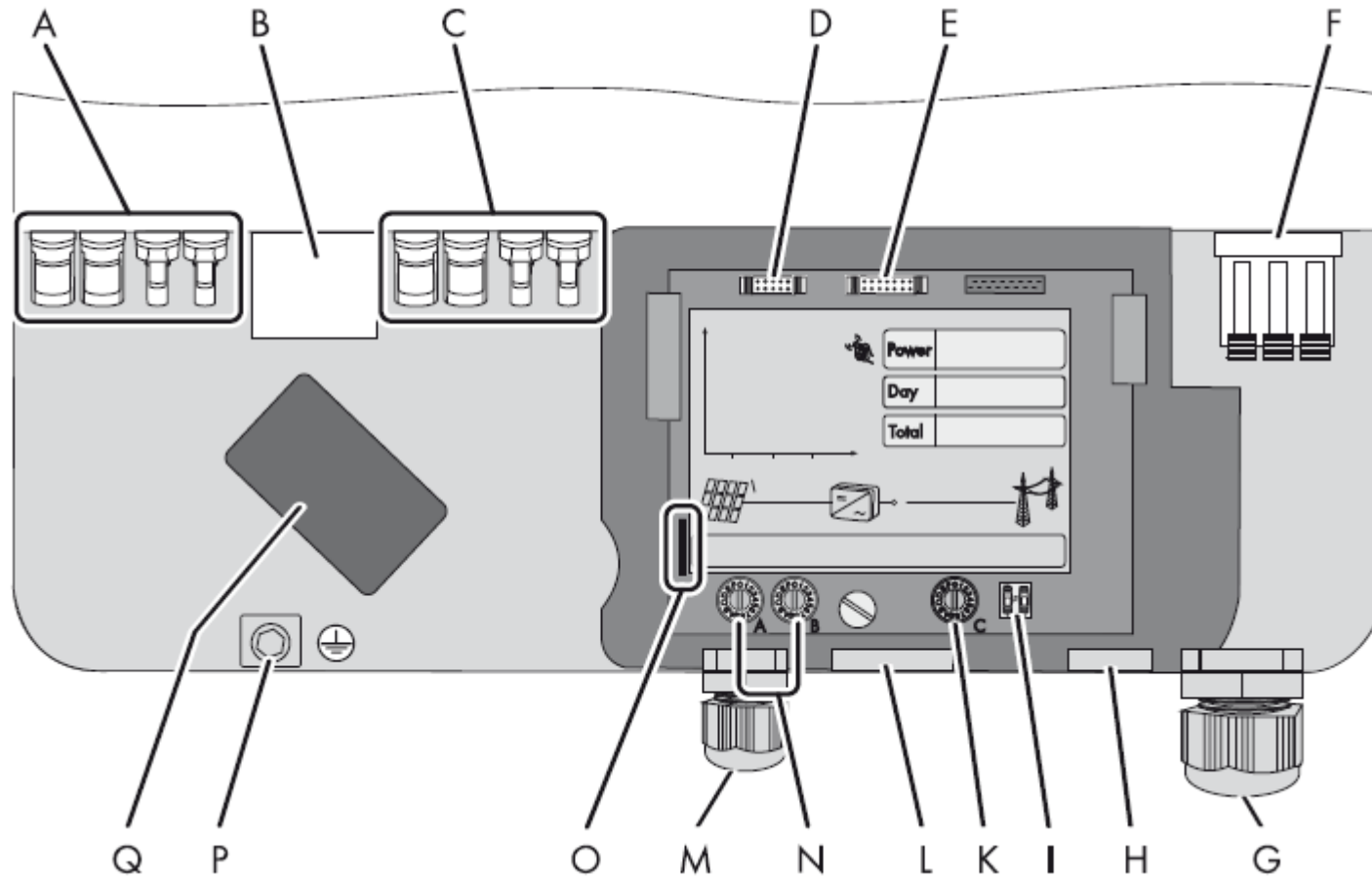
- recommended clearances
- ensures adequate heat dissipation
- ensures sufficient room to operate the DC switch-disconnector.



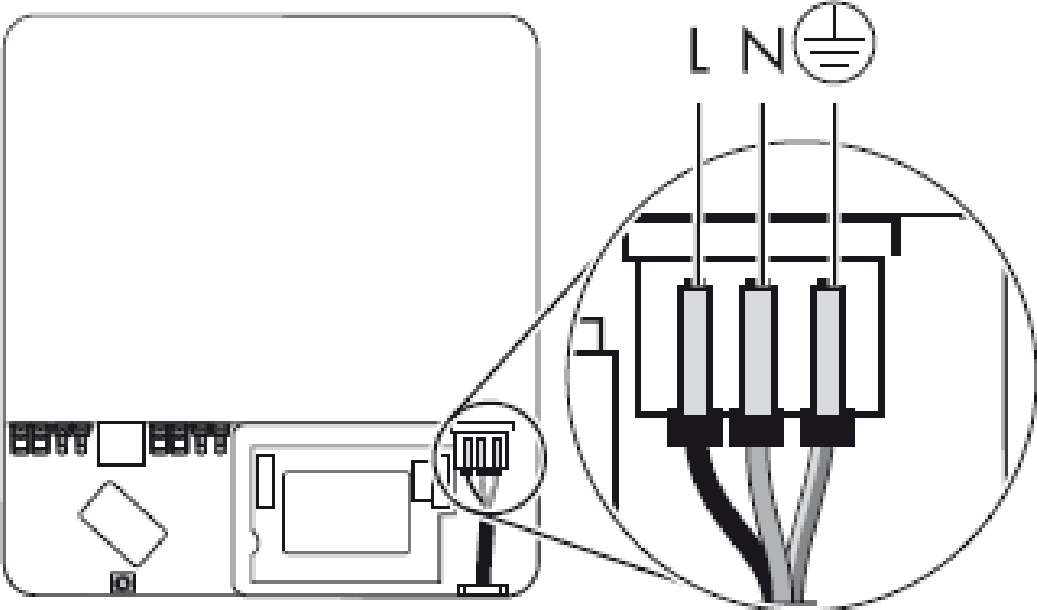
Inverter Mounting – STP 15000/20000TLEE-10



Connection Area

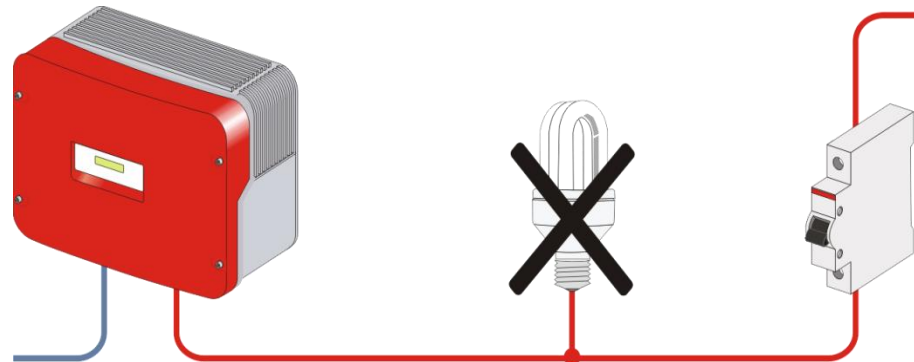


Connection Area : AC

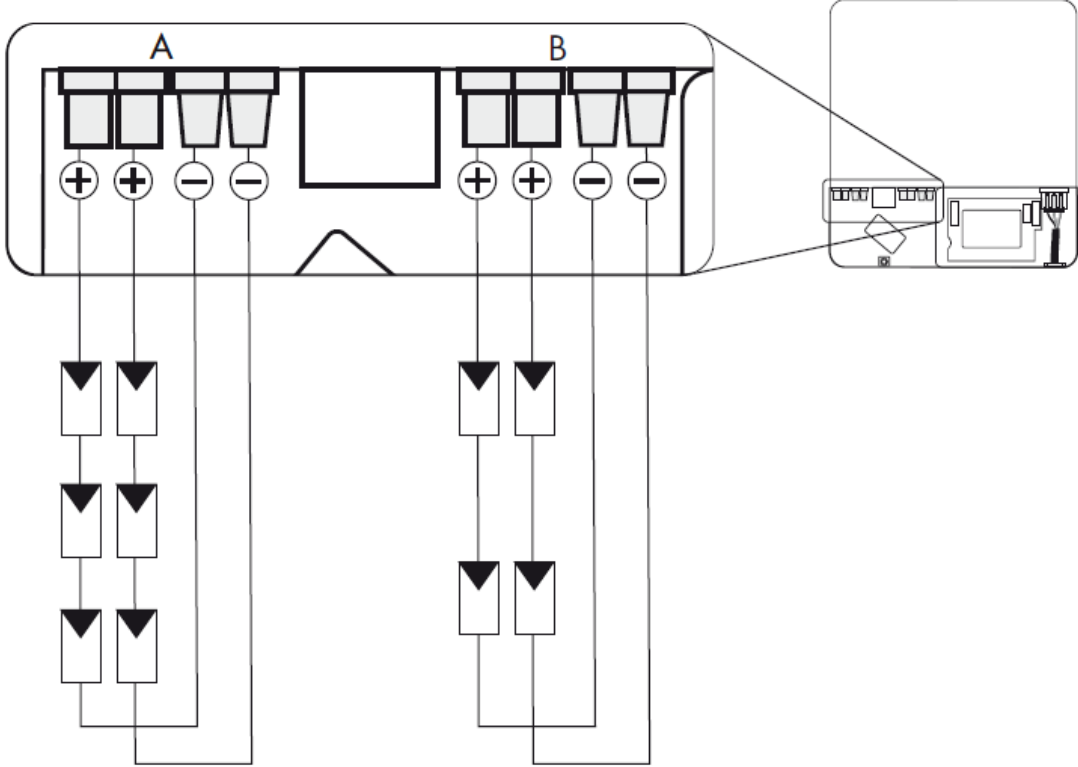


Electrical connection: AC side

- > Minimizing the cable resistance:
 - avoids the disconnection of the inverter
 - reduces line losses
- > Fixed terminal and screw connections avoid the risk of fire within the wiring
- > Secure all inverters via a proper line circuit breaker (see Technical Information for determination)
- > Do not connect any further loads to the power circuit

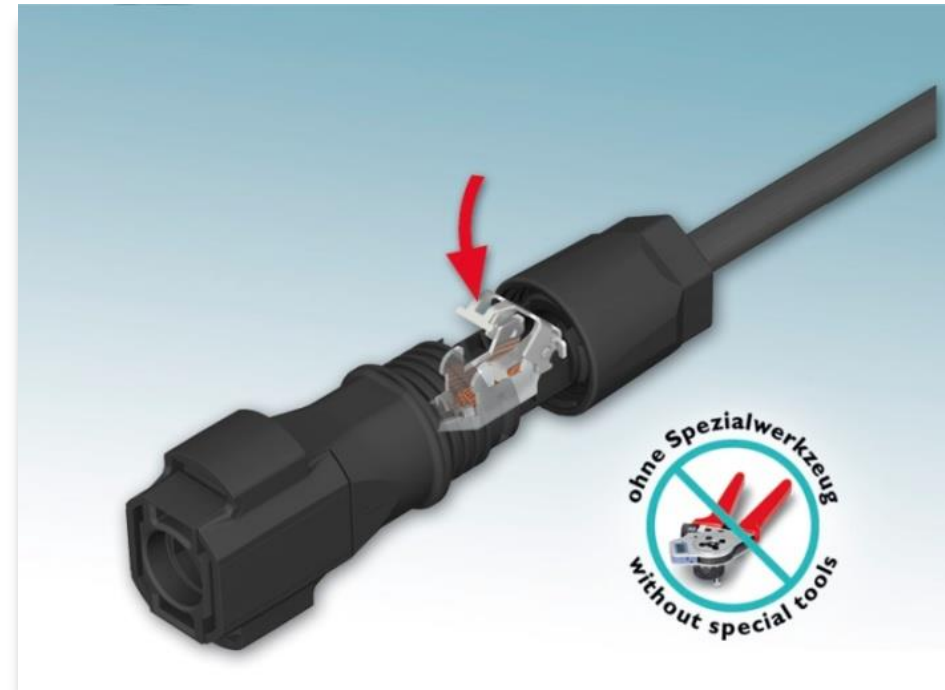


Connection Area : DC

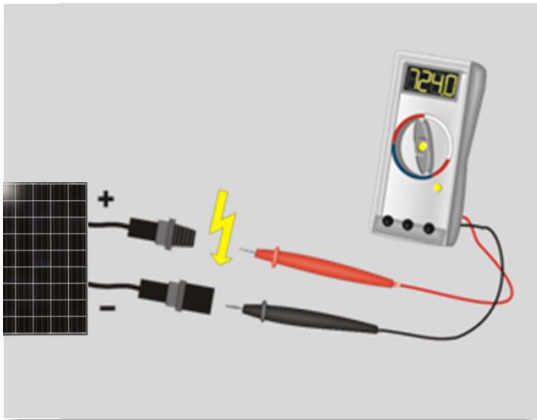


"SUNCLIX" – New DC plug system

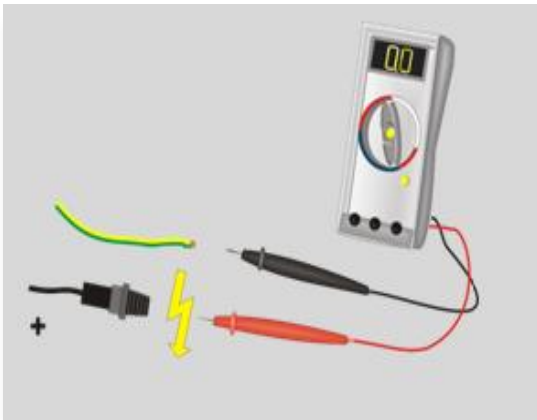
- > Comfortable and fast due to connection without tools
- > Conductors ranging from 2.5 to 6 mm²
- > High conductivity with 40 A already with 4 mm² up to 85 °C
- > Secure interlocking using click connections
- > Easy to unlock with a standard screwdriver - even if plugs are close together
- > Cost-effective due to field connector included in delivery



Electrical connection: DC side



- > Checking the PV generator
 - > voltage and polarity
- > PV generator voltage < maximum input voltage of the inverter



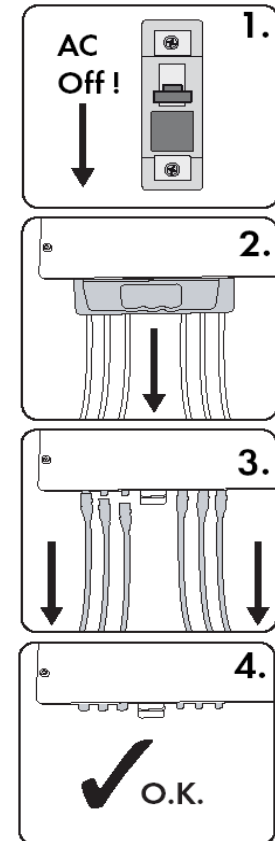
- > Checking the voltage of the PV generator connection to PE (DC "+" against ground, DC "-" against ground)
- > Integrating the module frame and rack of the PV generator into the potential equalization

Electrical connection /disconnection of AC side

Read the manual!

> Tasks

- Disconnection the inverter from PV generator
- Avoidance of arcing
- Disconnecting process:
 - Step 1: Switch off the grid
 - Step 2: Switch off by pulling ESS handle
 - Interrupting the current flow
 - Step 3: Disconnecting all DC connectors Without arcing



▶▶ Safe disconnection from PV generator complete

Inverter monitoring

ENERGY
THAT
CHANGES



Objectives of plant monitoring

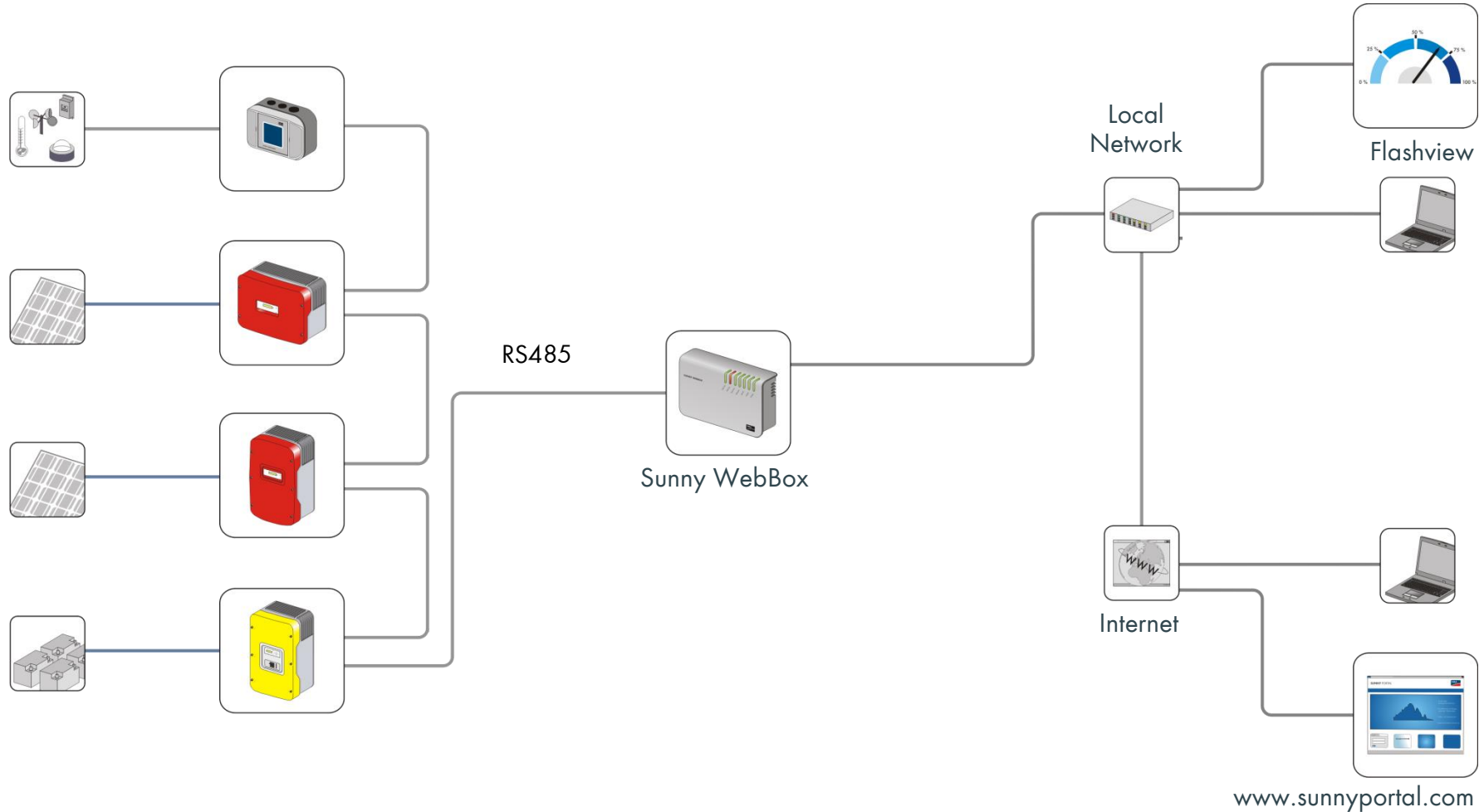
> Check

- Energy production
- Display of instantaneous values, e.g. feed-in power
- Continuous recording of plant data
- Graphic presentation of recorded data
- In case of an operational failure, signaling is guaranteed by the connection of warning devices on-site or by telecommunication
- Early detection of operational failures

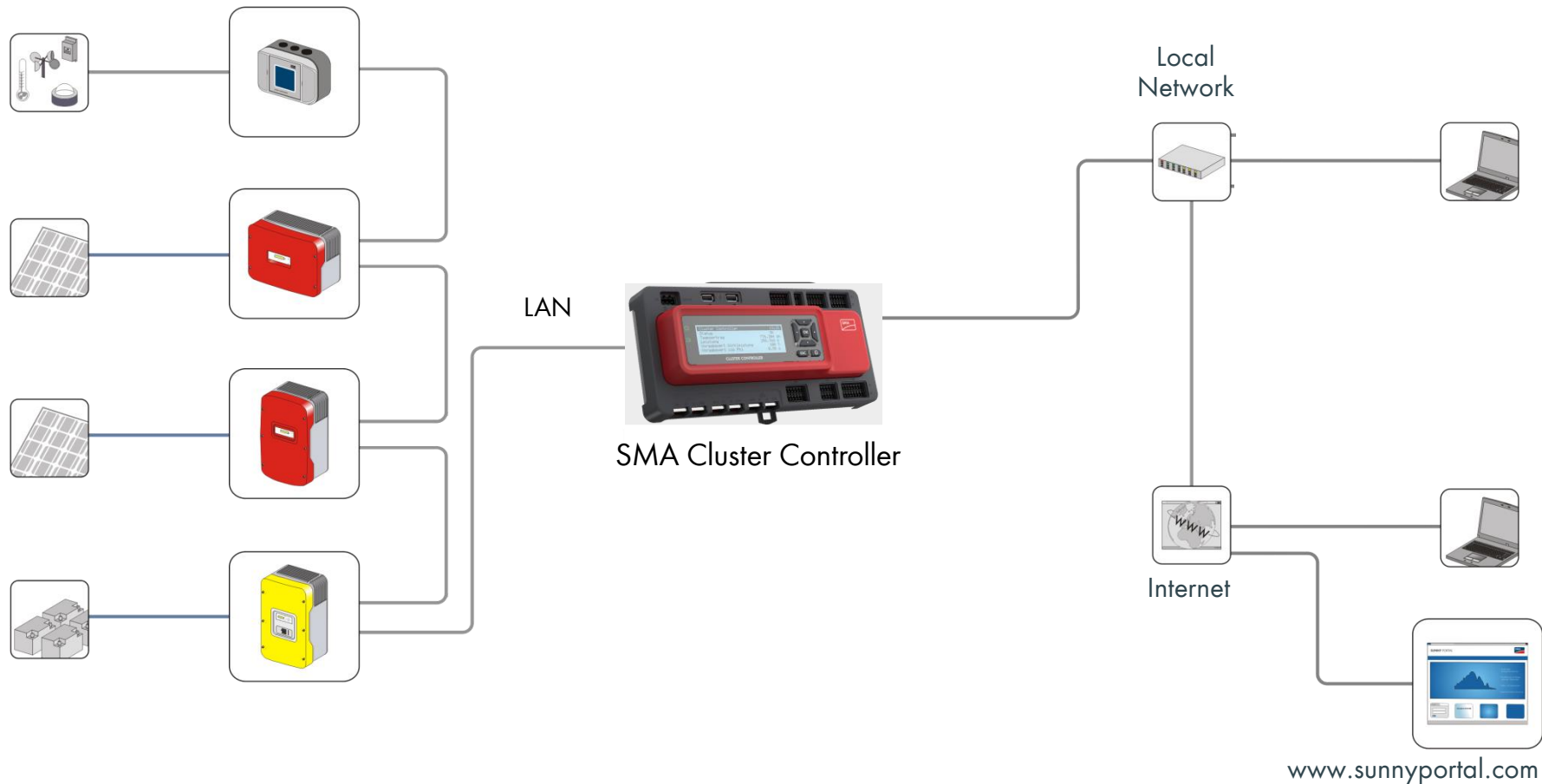
> Control

- Optimization of device parameters, e.g. to adjust the disconnection criteria (consulting your electric power company will be necessary!)

Standard communication with RS485



Standard communication with Speedwire



Webconnect



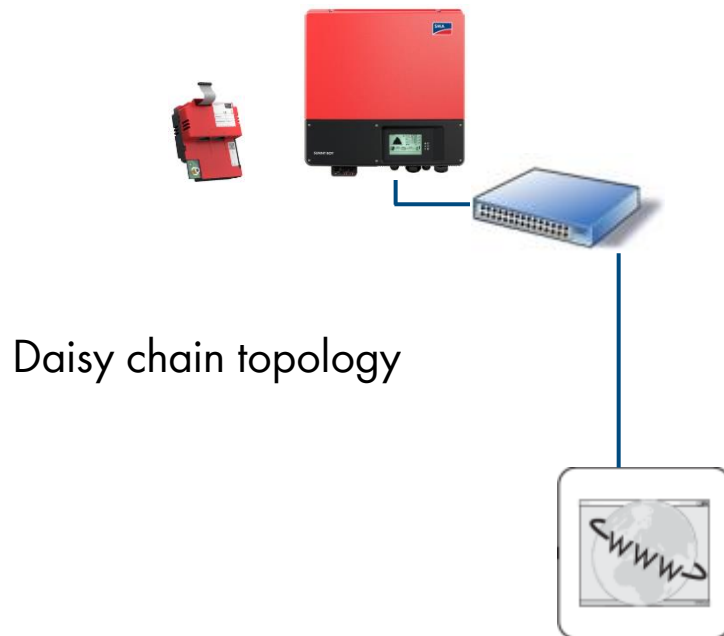
Use the advantages of the integrated Webconnect function

- > Direct connection to the existing router possible
- > Online control of small PV plants up to max. 4 Inverters
- > Direct connection to Sunny Portal without add. data-logger
- > View of the most important data for private user in Sunny Portal

▶ Simple, Fast, Secure

▶ Plug & Play

Speedwire/Webconnect up to 4 inverters without monitoring device



The screenshot shows the SUNNY PORTAL web interface. The header includes the SMA logo and a language dropdown set to 'en'. The main content area features a banner with a solar panel array and a power generation graph, accompanied by the following bullet points:

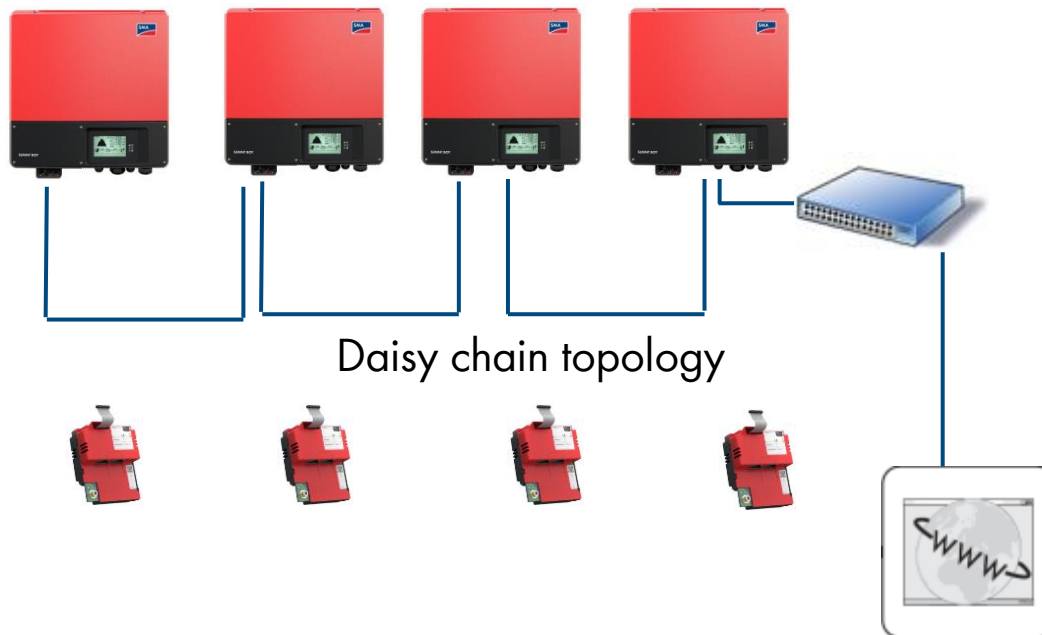
- Comfortable plant monitoring for beginners and professionals
- Display of yield, power, earnings and more
- Status messages via e-mail to PC and mobile phone
- Free data storage

Below the banner is a login section with fields for 'Email:' and 'Password:', a 'Login' button, and a 'Forgot your password?' link. To the right is a 'PORTAL OVERVIEW' section with a table of data:

	Wednesday	Current
YIELD	13,083	
PROD. ENERGY	5,66	
PRODUCED COST	3,96	€

At the bottom, there are two promotional tiles: 'Energy Plants' and 'Pilotly available plants'. The footer contains the copyright notice: '© 2015 Solar Technology AG | Start page | Information | User manual | FAQ | Terms and conditions | Support'.

Speedwire/Webconnect up to 4 inverters without monitoring device



The screenshot shows the Sunny Portal web interface. At the top, it says 'SUNNY PORTAL | TP: English' and the SMA logo. Below is a navigation bar with a solar panel image and a blue background with a sun icon. The main content area features a 'PORTAL OVERVIEW' section with a table of data:

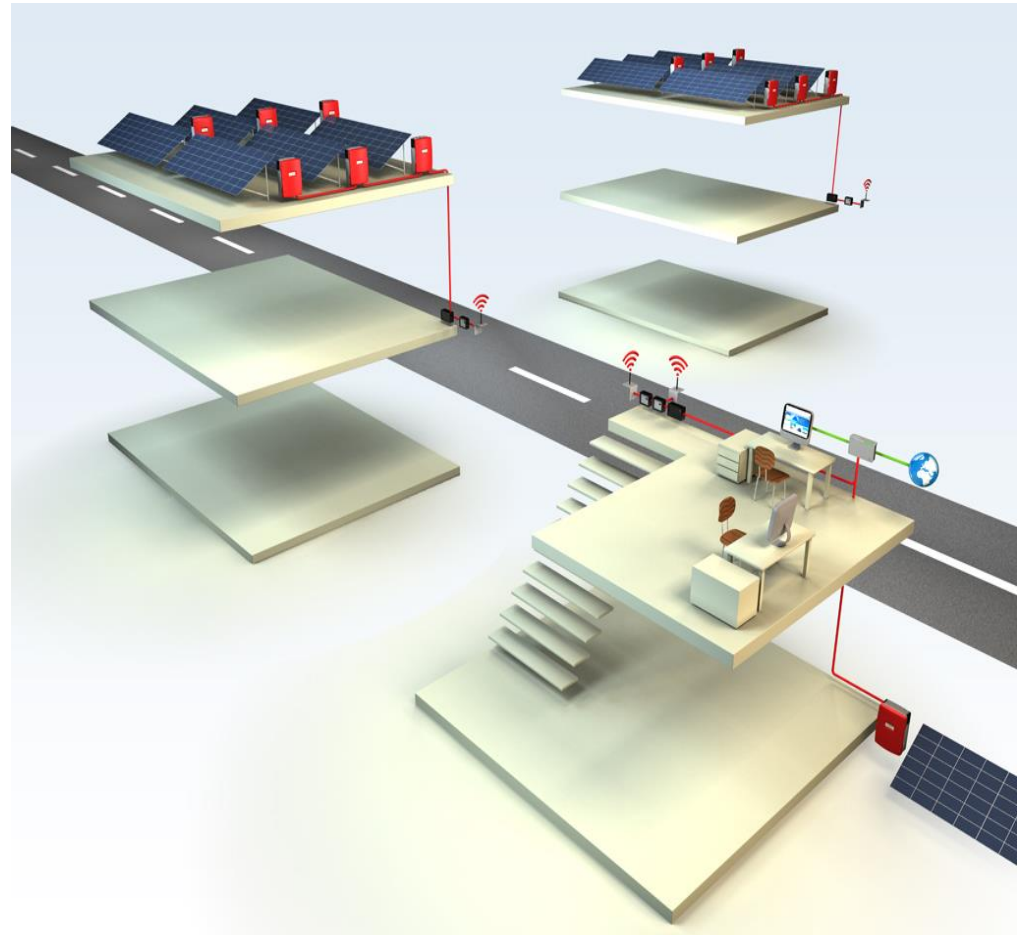
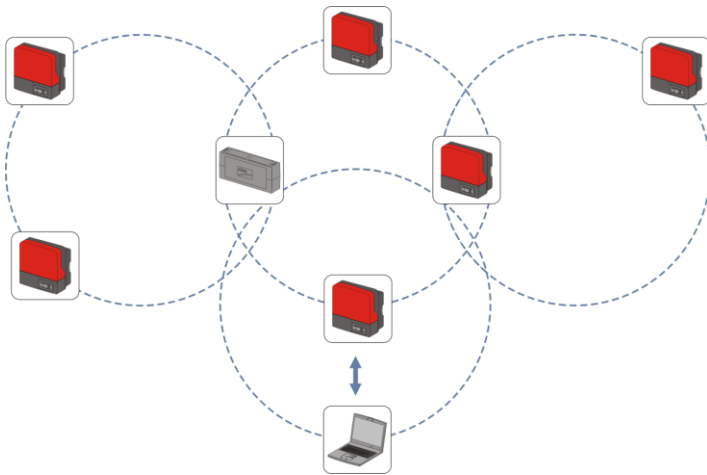
Parameter	Current Value
INVERTER	13,083
TOTAL ENERGY (kWh)	5,66
PRODUCED kWh (kWh)	3,96

Other elements include a login form with fields for 'Email:' and 'Password:', a 'Login' button, and a 'Forgot your password?' link. There are also several small images and text boxes, including one that says 'Publicly available plants'.

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Standard communication with SMA Bluetooth® Wireless Technology

- > Automatic and intelligent meshing
- > Up to 50 participants
- > Fast and reliable



Country certificate



การไฟฟ้านครหลวง
Metropolitan Electricity Authority

Inverter features need to have

- > **High efficiency**
- > **Reliability**
- > **Protection feature**
- > **Grid monitoring**
- > **Grid management**
- > **Easy monitor and control**
- > **Easy installation**
- > **Country certificate**





Energy that Changes

Thank you for your attention
www.sma.de