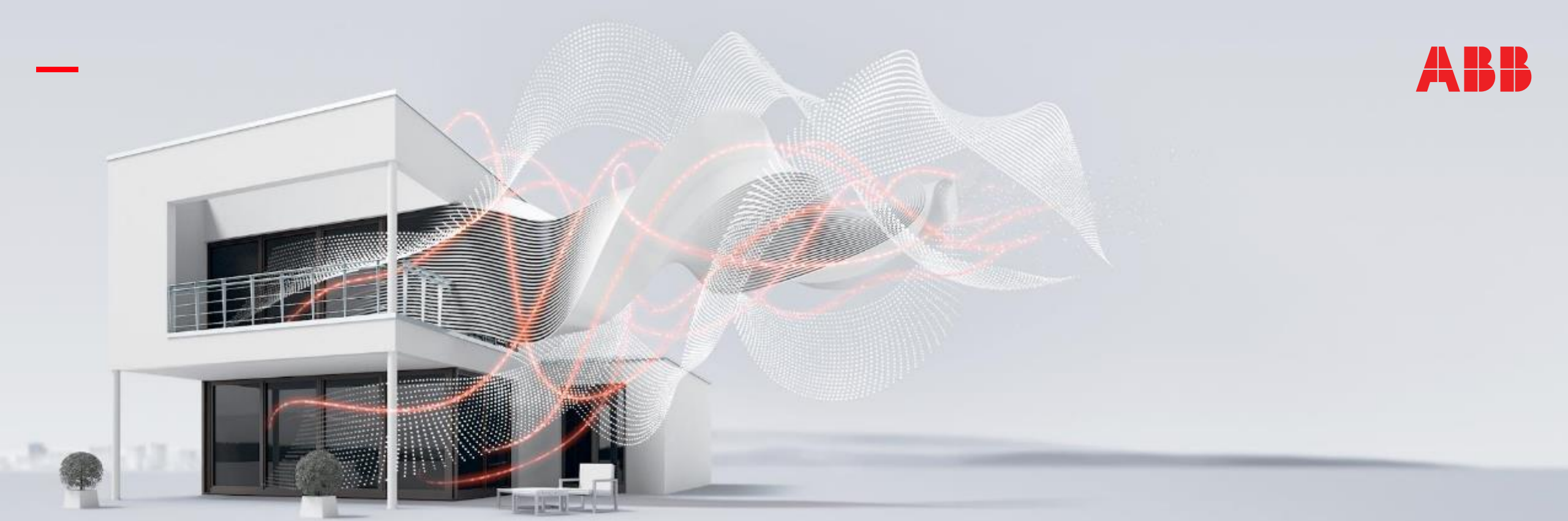


12 JULY 2019, MEDELLIN

ABB

Soluciones Integradas para Plantas de Generación FV a la red

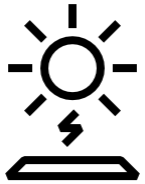
Gianluca Pieralli, Regional Sales Manager Americas – Solar

— Soluciones Integradas para Plantas de Generación FV a la red

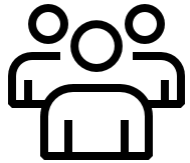
- ABB Global Footprint
- PVS 50/60
- PVS 100/120
- PVS 175
- Solar Integrated Products

ABB Business Unit Solar

Count on our experience, expert knowledge and strong global footprint

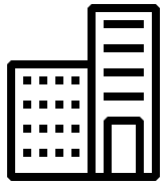


- **40** years experience in power conversion
- Over 15 years in solar
- **35+ GW** installed solar inverters base



- **~200** ABB solar service experts
- Optimized levelized costs of electricity and plant productivity

- Operate in **+100** countries with dedicated solar specialists in **30+** countries



- **2** solar inverter manufacturing sites
- **4** solar inverter R&D centers
- **6** new products and platforms in 2018
- **~2 million** inverters worldwide shipped

Global R&D and Operations - Italy

Pioneer center in PV inverter technology

Valdarno
formerly Power-One headquarter

3 GW Inverter manufacturing capacity

R&D, Operations, S&M and Service

Global R&D and Operations - India

Newly expanded plant, in a fast growing ABB's Campus

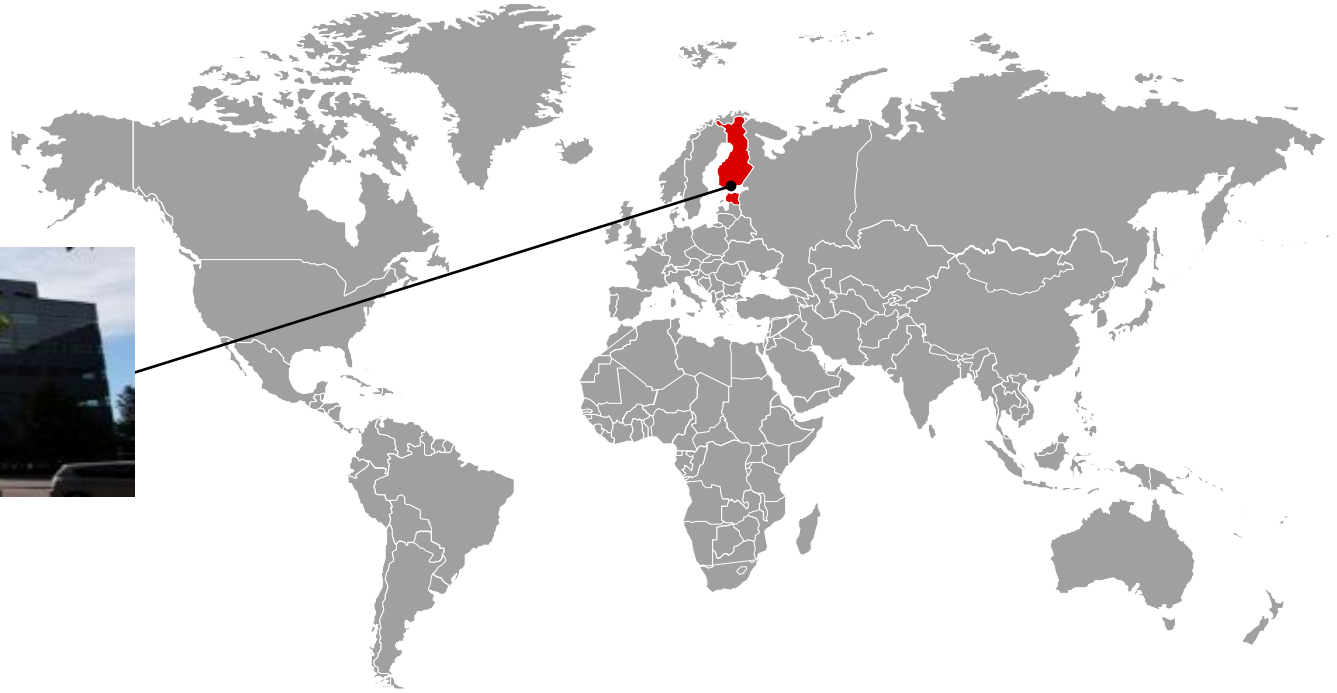
Nelamangala located in the center of the Country

3 GW Inverter manufacturing capacity

R&D, Operations, S&M and Service

Global R&D - Finland

Strong ABB’s centers in multiple sectors, power conversion on top

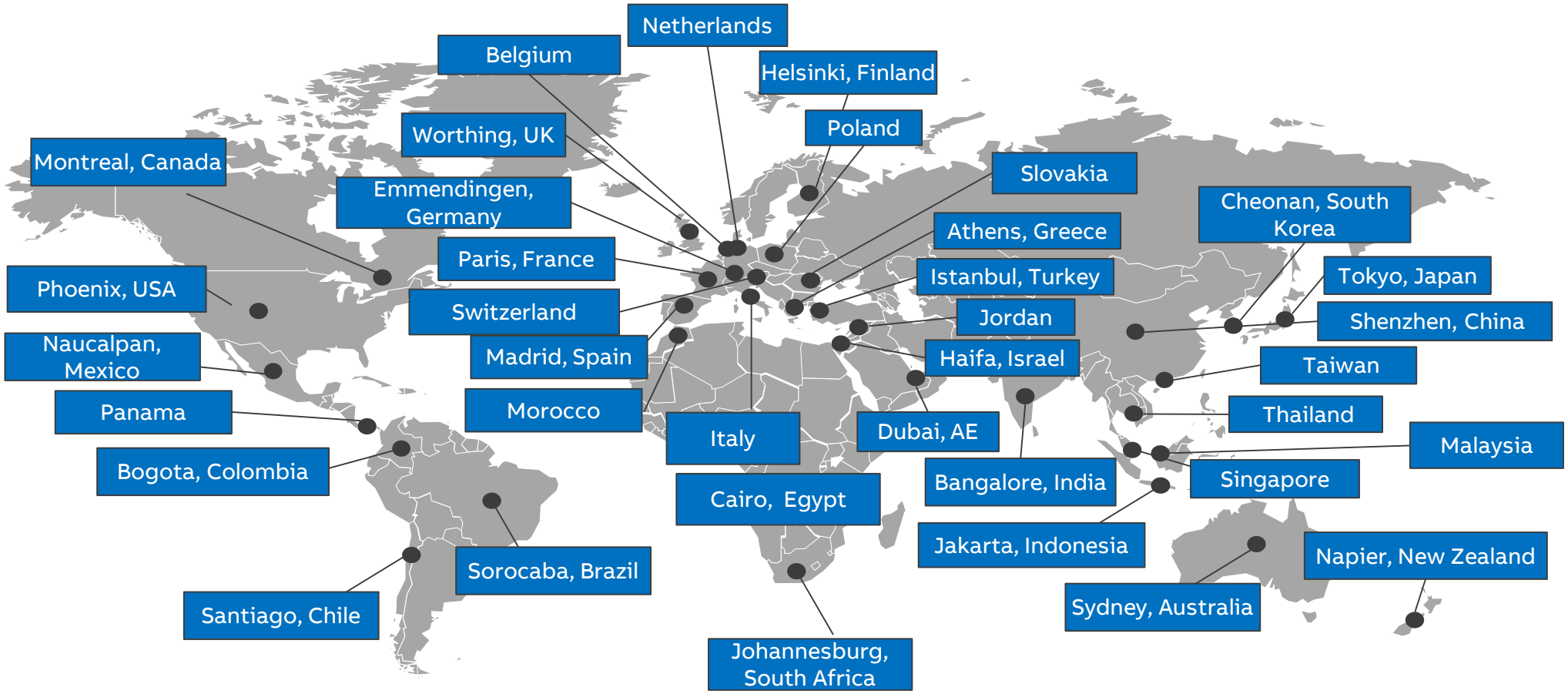


Helsinki
historical ABB’s competence centers

R&D, S&M and Service

Global presence – Service support

Well set-up global organization



Installed base

Over 35 GW in continued expansion across the globe

Split MW wise

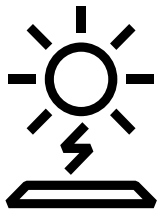
- <50% String
- >50% Central

ABB delivered Solar Solutions (Products & Systems)

The market segments where we play

From a kW all the way up to MWs

Fast and effective changes in a very dynamic market



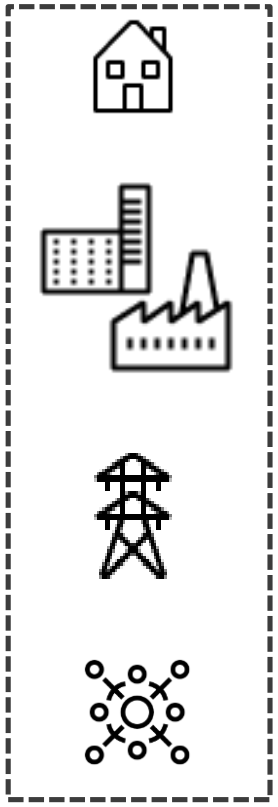
PG Solar

A wide offer with different **DC to AC** inverter technologies supported by Digital platforms

ABB Ability

DC

AC



Residential
1.2 to 6kw 1ph
5.8 to 8,5KW 3ph

Usually projects **below 10kW**

- All about rooftop, typically single phase, one or very few inverters
- High value to connectivity, user friendly

Commercial & Industrial
10 to 120KW 3ph

Between **10 to 5000kW**

- C&I roofs, all three phases, some or many inverters
- Flexibility, compactness and performances the keys

Utility
0,12 to 5MW

Above **5000kW**

- Massively ground mounted
- From LV to MV, always big and many units
- $/W, performances and O&M on top

Microgrid
20 to 60KW 3ph

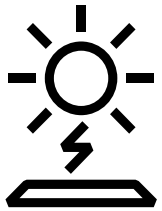
On/Off-grid projects

- From kw up to MW
- Rural installations primarily in Emerging countries

The market segments where we play

From a kW all the way up to MWs

Fast and effective changes in a very dynamic market



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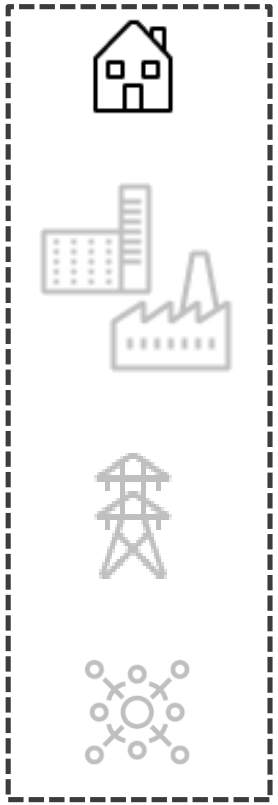

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Microgrid

On/Off-grid projects

- From kw up to MW
- Rural installations primarily in Emerging countries

UNO-DM-PLUS

Single phase string inverter – 1.2 to 6kW

Proven technology and smart grid capabilities for residential application

- Easy to install
- Smart Inverter Capabilities
- Future proof
- High reliability
- Advanced Communication

REACT 2

Single phase string inverter + Storage – 3.6kw to 5kW PV with 4 to 12kWh

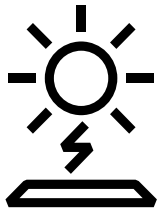
Shaping the next generation of smarter homes

- Easy to install
- High energy self-reliance
- High energy efficiency
- Maximized flexibility
- High versatility
- Advanced Communication

The market segments where we play

From a kW all the way up to MWs

Fast and effective changes in a very dynamic market



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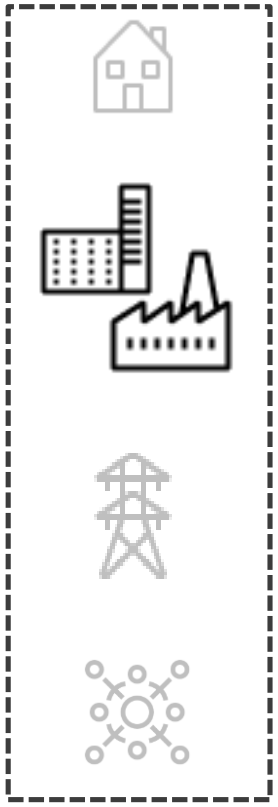

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Microgrid

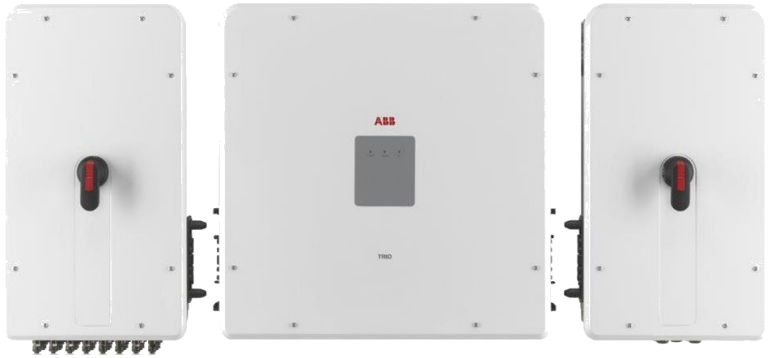
On/Off-grid projects

- From kw up to MW
- Rural installations primarily in Emerging countries

PVS-50/60-TL

Product family evolution

TRIO-TM-50.0/60.0



DC Wiring box | Power module | AC Wiring box

3 independent boxes

Weight: **95 kg**

Volume: **270 dm3**

PVS-50/60-TL

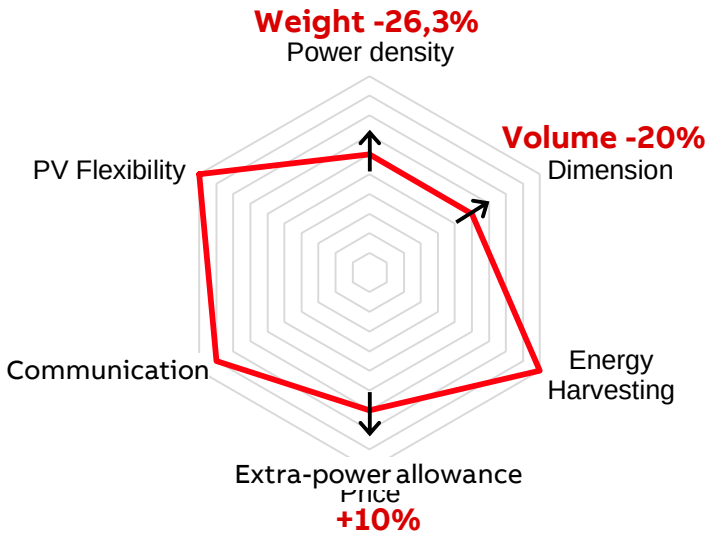
DC & AC Wiring section | Power module

Single box with 2 compartments

Weight: **70 kg**

Volume: **215.7 dm3**

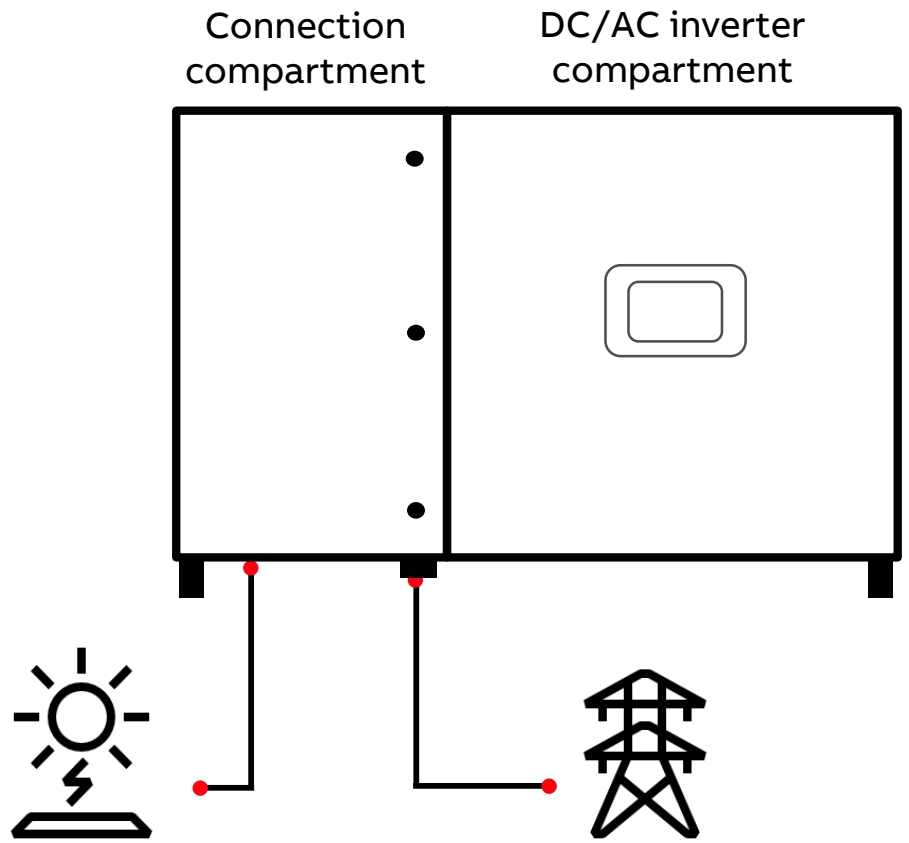
Improvements



PVS-50/60-TL

Electrical features

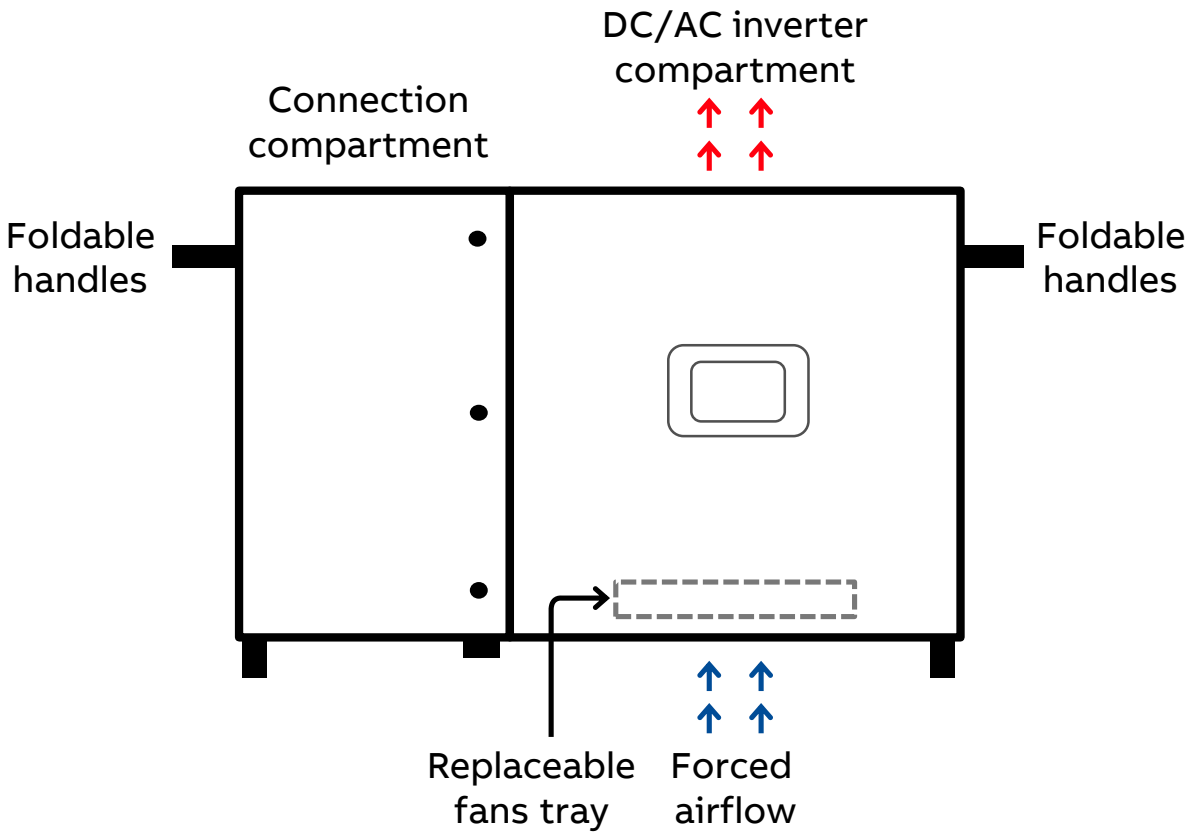
	PVS-50-TL	PVS-60-TL
AC voltage	400 Vac	480 Vac
AC output power	50000 VA	60000 VA
AC extra power (≤ 30°C ambient)	+10% (55kW)	+10% (66kW)
Independent MPPT	1 (standard and -S version) 3 (-SX and -SX2 version)	
Number of DC input pairs for each MPPT (SX and SX2 version)	5	5
DC connection type	Screw terminal block (Standard and -S version) PV quick fit connector (-SX and -SX2 version)	
Efficiency: Max/EU/CN	98.3%/98.0%/98.2%	98.5%/98.0%/98.3%



PVS-50/60-TL

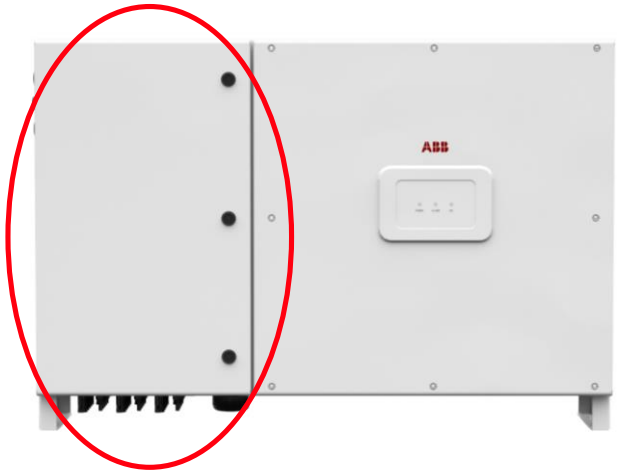
Mechanical features

	PVS-50-TL	PVS-60-TL
Dimension (H x W x D)	750 mm x 1100 mm x 261.5 mm	
Weight	70 kg (SX version)	
Maximum operating altitude	4000m with derating above 2000m	
Mounting system	Vertical/ Horizontal	
Environmental Prot. rating	IP65 (IP54 for cooling section)	
Cooling	Forced air – replaceable fan tray	
Temperature range	-25°C….+60°C (der. 45°C)	
Front cover for connections	Hinges and cam-latch locks (screw-less)	



PVS-50/60-TL

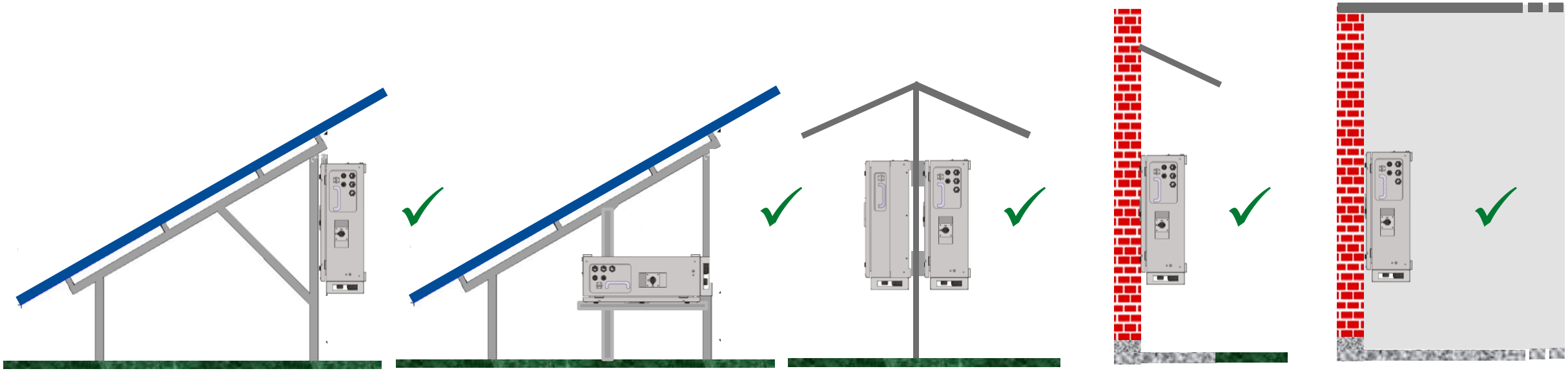
Available versions and options



Versions	Input connections	String fuses	DC disconnect switch	SPD Type II (DC + AC)	Additional options		
PVS-50/60-TL	Terminal blocks (1 MPPT)	–	–	Yes	–	Display	Grounding Kit
PVS-50/60-TL-**S**	Terminal blocks (1 MPPT)	–	Yes	Yes	–		
PVS-50/60-TL-**SX**	Quick connectors (3 MPPTs)	Positive side only	Yes	Yes	–		
PVS-50/60-TL-**SX2**	Quick connectors (3 MPPTs)	Positive + Negative side	Yes	Yes	DC SPD Type I+II		

PVS-50/60-TL

Mechanical installation



Below panels

Below panels

Roof

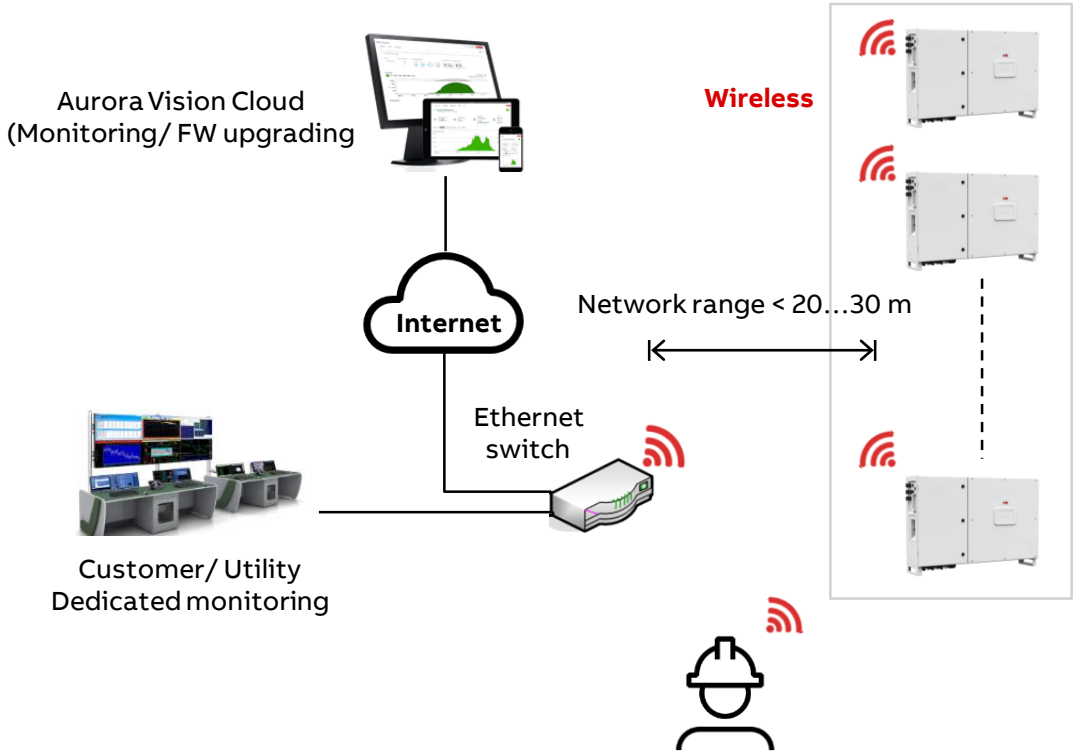
Roof

Indoor with air conditioning

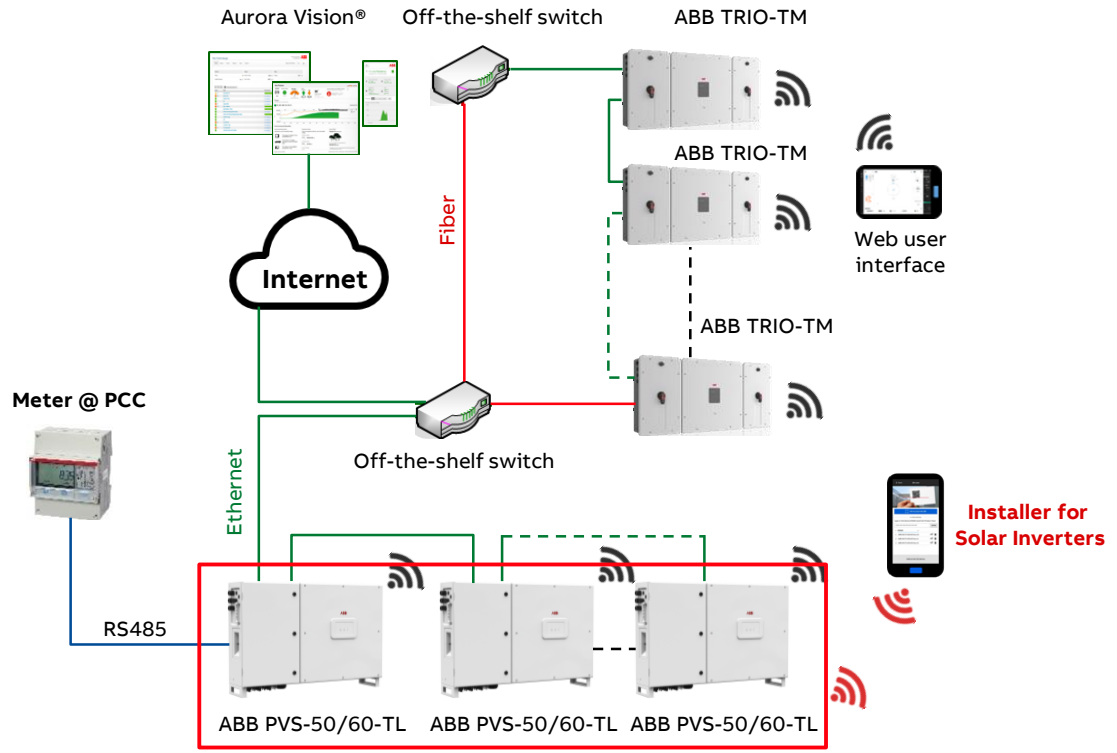
PVS-50/60-TL

Comms & Control

Communication over wireless network



Communication over Ethernet



PVS-50/60-TL

Three phase string inverter – 50/60 kW

One inverter, many applications

- Increased power density
- Fast commissioning
- Maximized flexibility
- All-in-one design
- Cutting-edge Communication & Control
- Maintenance friendly

PVS-100/120

Three phase string inverter – 100/120 kW

More power, more energy, more saving

- High power density
- Easy to install
- Maximized flexibility
- Combiner-free design
- Advanced Communication
- O&M friendly

PVS-100/120

More power, more energy, more saving

High power density

50% fewer inverters required on site, reducing installation and logistic costs

IP65 enclosure for a better reliability

Smart cooling system for higher performances

Easy to install

Save time and costs on site preparation and commissioning

Vertical and horizontal mounting, on the wall as well as on the PV panel mounting structures

Maximized flexibility

6 independent MPPTs for an easiest configurability

Wide input voltage range **480-850V** for a large adoption

Combiner-free design

All in one integrated string combiner reduces capex and opex costs

24 inputs with protections and measures each

Advanced Communication

Commission and troubleshoot all units with **standard mobile devices** from a single access point

Closed **loop control** at cluster level

Integrated datalogging with direct connection to **ABB's cloud service**

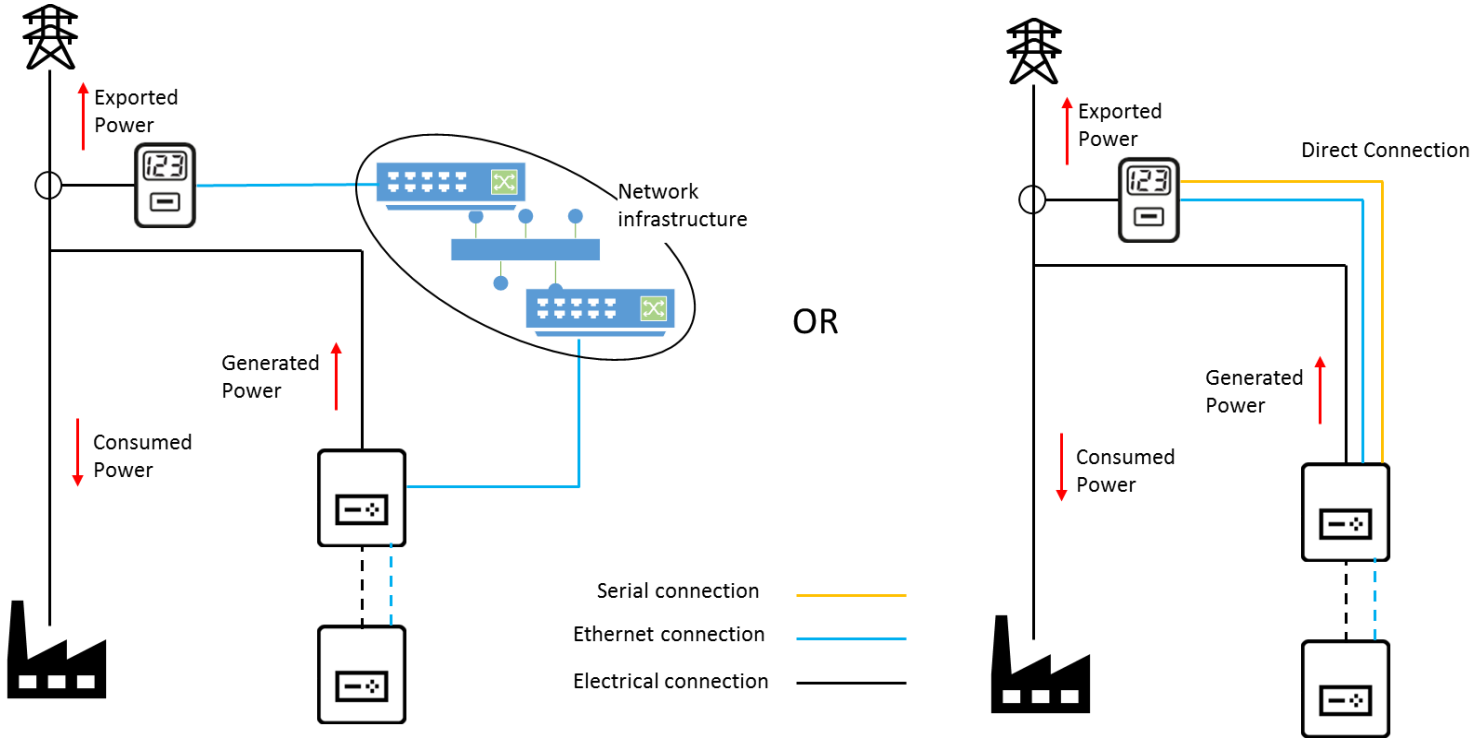
O&M friendly

Modular construction & Advanced cooling system minimized O&M costs

2 construction boxes, combiner units on the bottom

PVS-50/60/100/120-TL

One inverter, many applications – 0 injection system



PVS-50/60/100/120-TL

One inverter, many applications – 0 injection system

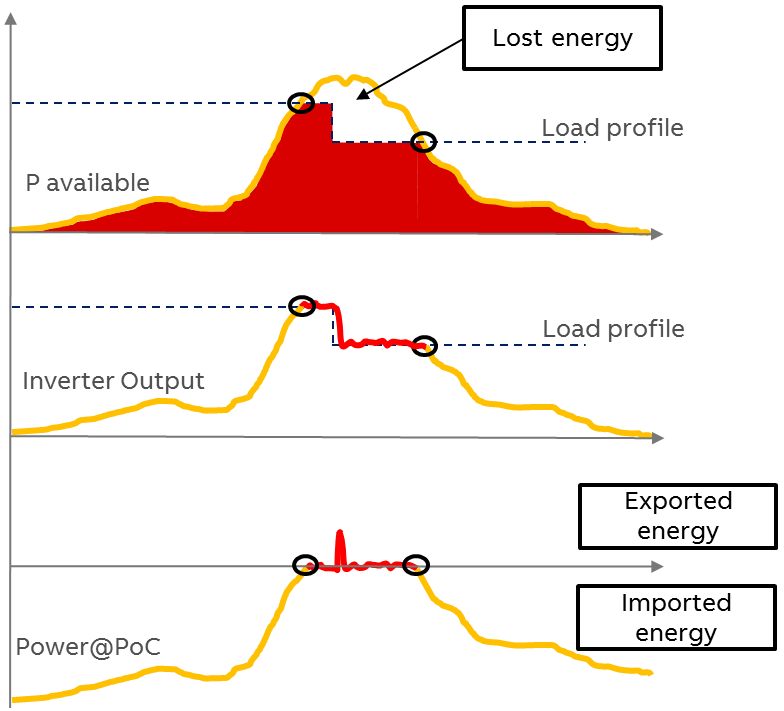


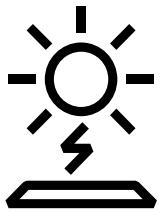
ABB Export Limitation function is being certified according the following standards and testing protocols:

- AusNet services: Export limits for Embedded Generators up to 200 kVA connected at Low Voltage (SOP 33-06)
- ERC Rules and Regulation on Thailand's Solar Rooftop Programme (MEA: Zero Power Injection)

The market segments where we play

From a kW all the way up to MWs

Fast and effective changes in a very dynamic market



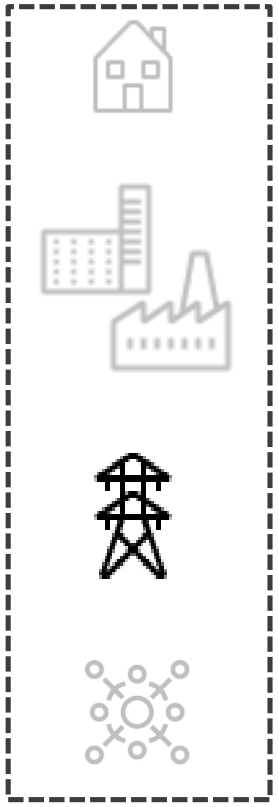
PG Solar

A wide offer with different **DC to AC** inverter technologies supported by Digital platforms

ABB Ability

DC

AC



Residential

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- High value to connectivity, user friendly

Commercial & Industrial

Between **10 to 5000kW**

- C&I roofs, all three phases, some or many inverters
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Utility
0,12 to 5MW

Above **5000kW**

- Massively ground mounted
- From LV to MV, always big and many units
- $/W, performances and O&M on top

Microgrid

On/Off-grid projects

- From kw up to MW
- Rural installations primarily in Emerging countries

PVS-175-TL: There’s a new power in Solar

Overview

PVS-175 1500Vdc/800Vac a unique, six-in-one product

- **185kVA @30°C/ 175kVA @40°C:** The World’s **Highest Power Inverter** in the String Category
- **Modular Construction:** with detachable wiring box
- **Remote Fw update & parameters setting**
- **Fuse-free design:** Minimize EBoS and O&M
- **12 independent MPPTs** for the highest yield and configurability in all ground conditions
- **Installer App:** 70% faster wireless plant commissioning

PVS-175-TL

Data-sheet

Inverter key parameters

- 185kW@30°C, 175kW @40°C
- Max Input Voltage 1500Vdc
- **Vac = 800Vrms 3-ph/ 3 wire, 50/ 60Hz**
- **12 Independent MPP/ 24 strings**
- Fuseless DC combiner design
- VMPPT = 850 – 1350 Vdc, full power

User Interface

- Standard LEDs
- Integrated Web User Interface for managing inverter
- IOS and Android installation app for multiple inverter commissioning
- Standard level access to Aurora Vision remote monitoring service

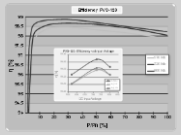
Construction, weight, volume

- IP65
- Forced Air cooling
- Two box construction
- Overall weight ≈ 153kg (76kg + 77kg)

Communication

- 2 x Ethernet;
- Wi-Fi Channel
- 1 x RS485;
- Modbus RTU/ TCP (Sunspec compliant);
- Integrated datalogger and direct connection to Aurora Vision remote portal

Efficiency



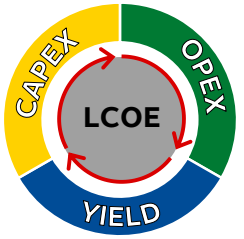
- Max. Efficiency: 98,7%
- EU Efficiency: 98,4%
- CEC Efficiency: 98,4%

In/ Out protections

- Type 2 Surge arrester (both DC and AC)
- Insulation monitoring control per IEC 62109-2
- **DC Series Arc Fault Circuit Interrupter (optional)**

PVS-175-TL

Setting a new trend in the solar inverter technology



System cost breakdown evolving towards an higher share of BoS and O&M

Identifying other areas for cost optimization while preserving the yield

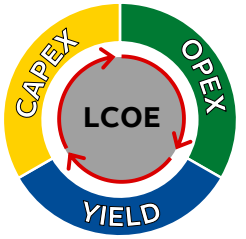
$$LCOE = \frac{CAPEX + OPEX}{YIELD}$$

How inverters can support the solar industry to tackle these challenges?

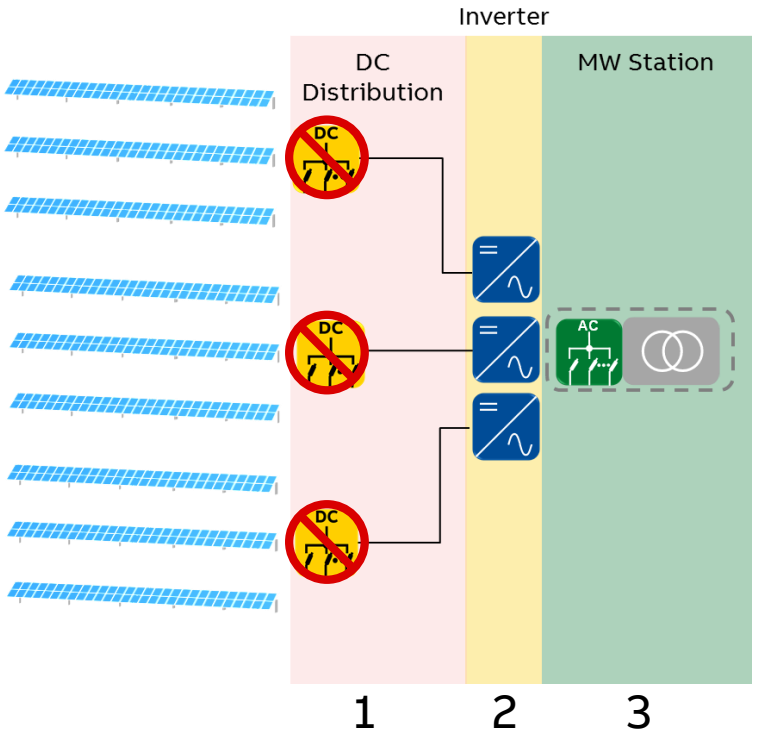
	CAPEX	OPEX	YIELD
Evolving from component to a complete «all-in-one» solution Modular construction with detachable wiring box	↓	↓	
Power electronics enabling further system-level cost savings 1500Vdc/ 800Vac = highest power density and cluster capacity	↓	↓	
Multi-MPPT Technology, offering maximum energy yield Fuse & DC combiner free design, minimizing EBoS and O&M	↓	↓	↑

PVS-175-TL

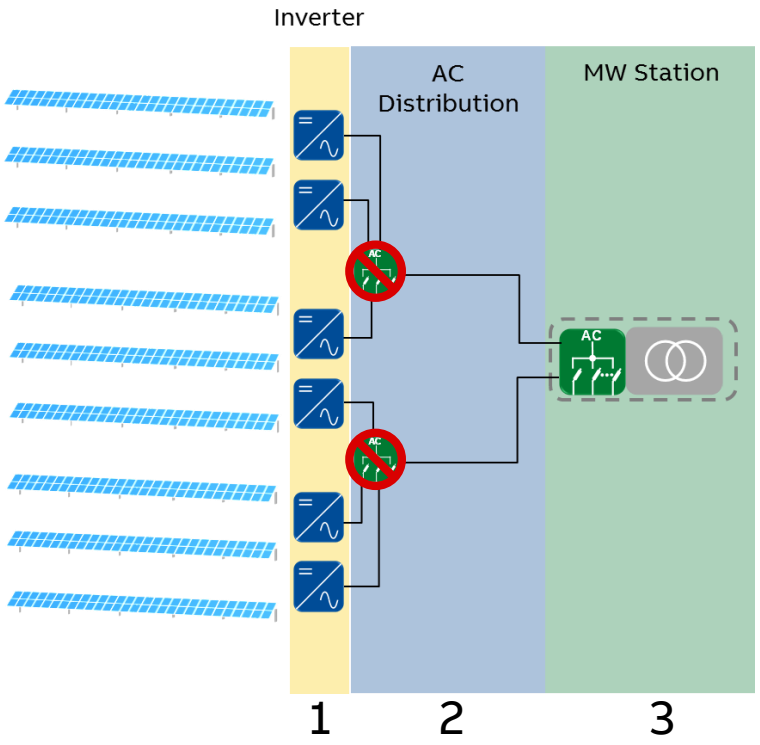
Evolving from component to a complete «all-in-one» solution



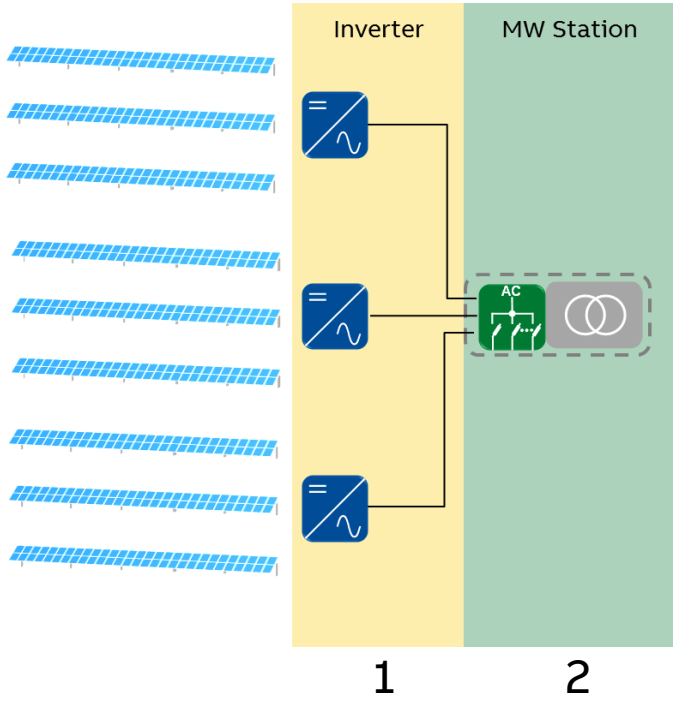
Virtual Central Inverter



String Inverter

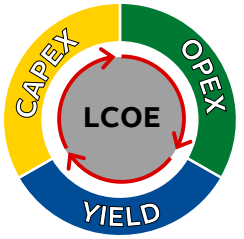


"All-In-One" String Inverter



PVS-175-TL

Evolving from component to a complete «all-in-one» solution

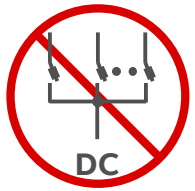


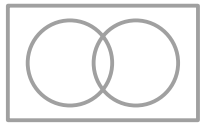
ABB's PVS-175 the «all in one solution»

Virtual Central inverter

3 level design based on the use of:

- DC String combiner boxes: For each Inverter one DC combiner box is needed
- Inverters: Typical size: 100-150kVA
- Conversion station: N°1 or more is needed depending on the size of the Cluster. Generally not more than 25-30 input for each secondary winding

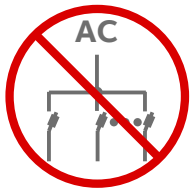


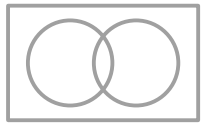


String inverter

3 level design based on the use of:

- Inverters: Typical size: 60-100kVA
- AC combiner boxes: Number depend to the project-design and inverter size. Generally 2 or 3 inverter outputs are combined in a single box
- Conversion station: N°1 generally is enough

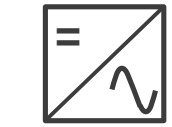


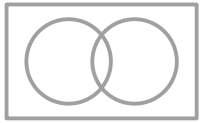


ABB's PVS-175

2 level design based on the use of:

- Inverters: 175kVA inverter
- Conversion station: N°1 generally is enough
- No recombiners are needed.

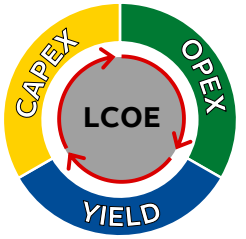




PVS-175 the «all in one solution»

PVS-175-TL

Enabling further cost savings with the world's highest power inverter in the string category



1500VDC allows high AC voltage!

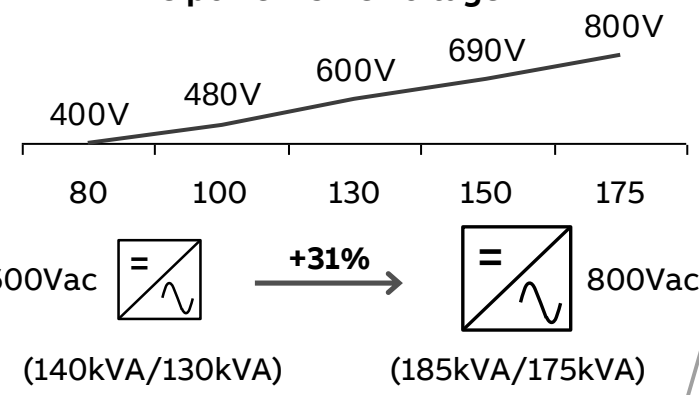
High AC voltage is enabled with DC/DC boosters and 1500Vdc input voltage

Single stage inverter reasonable max AC voltage ~ 600VAC, Dual stage inverter AC voltage can be increased to 800VAC

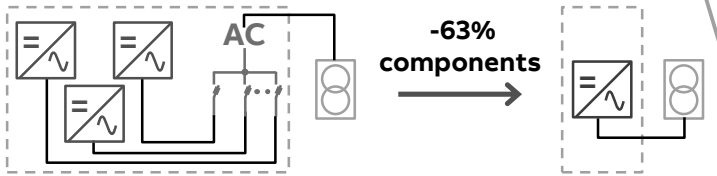
800VAC to reduce **Balance of System cost (i.e. AC side cabling)** and **enabling higher power units with same current (less units per power block)**

More power from the same enclosure

AC power vs AC voltage



Less units and resources are needed

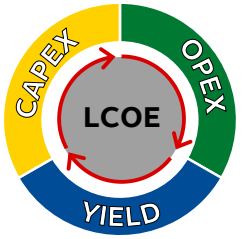


AC-BOS cost savings (LV distribution)

Bigger PV clusters may be designed

PVS-175-TL

Evolving from component to a complete «all-in-one» solution



ABB's PVS-175 the «all in one solution» – O&M benefit

Modular construction with detachable wiring box reducing installation and maintenance effort.

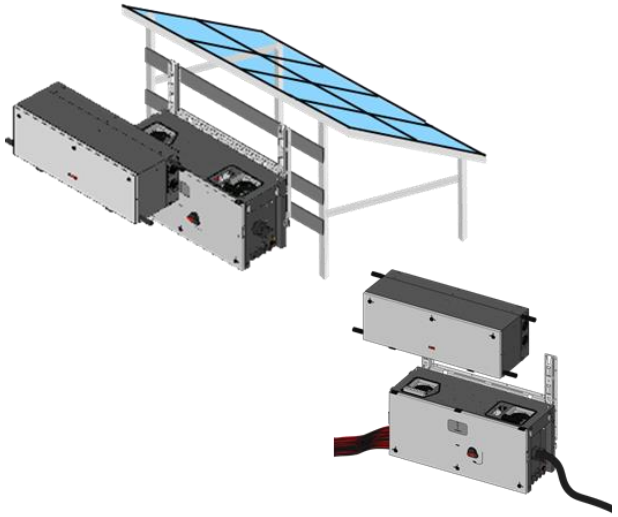
- Two box structure (power module ~76kg, wiring box ~77kg)

Benefits:

- **Two person can manage** the mounting of boxes
- **Power module can be easily replaced** without removing the wiring box.

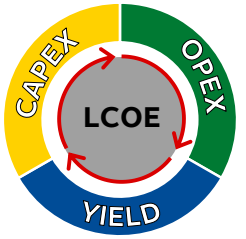
Cost saving on logistics:

- Wiring box/ inverter box **can be stocked separately**
- **Future local variants** of wiring box possible

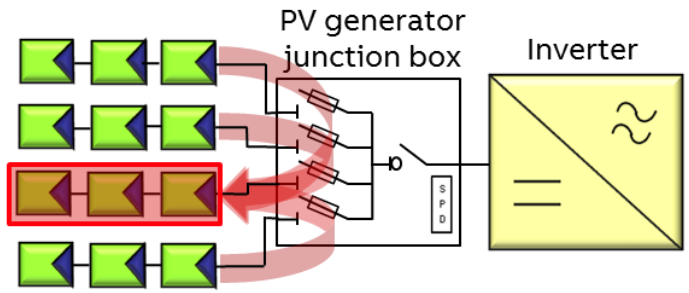


PVS-175-TL

Preserving maximum energy yield while reducing CAPEX and OPEX of the system



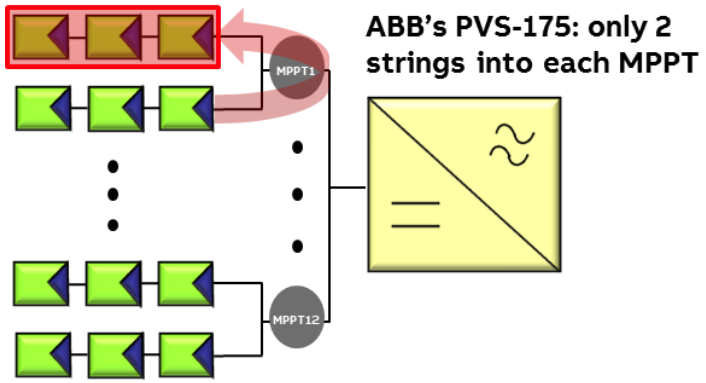
Fuseless technology benefit



The PV panels must be protected by reverse current according to manufacturer data-sheet. Generally, if 3 or more strings are connected in parallel, a reverse current protection must be used.

Fuses are prone to nuisance tripping over the years and this increase:

- **O&M cost** → Site inspections are needed to check and replace fuses
- **Energy yield losses**



ABB's PVS-175 with 12 MPPTs and only 2 strings into each MPPT no need fuses:

- **Simplify O&M → Cost Saving**
- **Avoid energy yield losses**

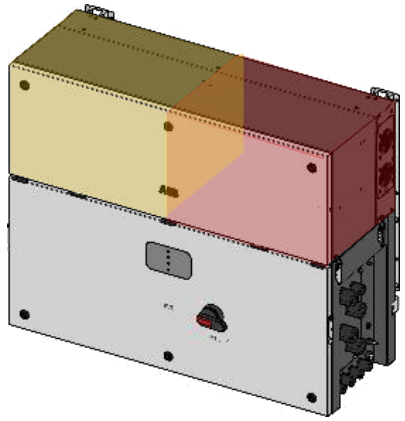
PVS-175-TL

Advanced cooling concept

Advanced cooling concept

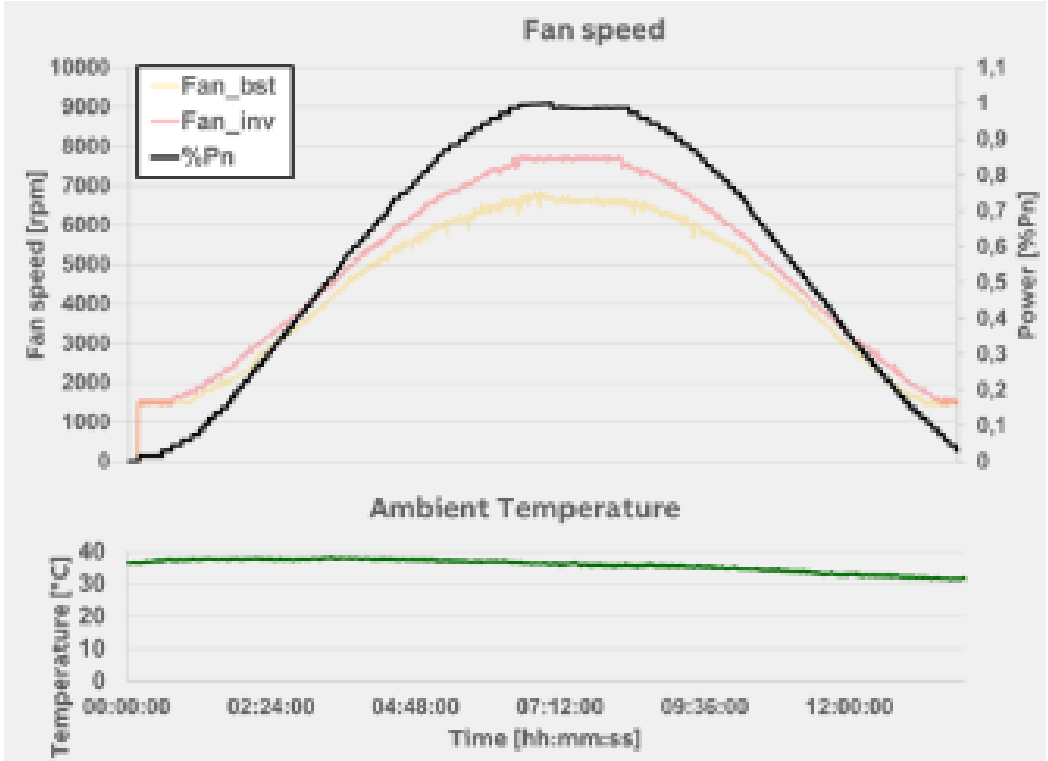
2 independent external air circuits:

- Booster on the left side
- Inverter on the right side



Benefits:

- **Increased lifetime** as temperature of components is kept under control
- **Fans speed modulation**, to reduce self consumption and preserve fan lifespan
- Wiring box temperature controlled (minimize thermal stress on fuse and contactor)



PVS-175-TL

Monitoring & control (user interface)

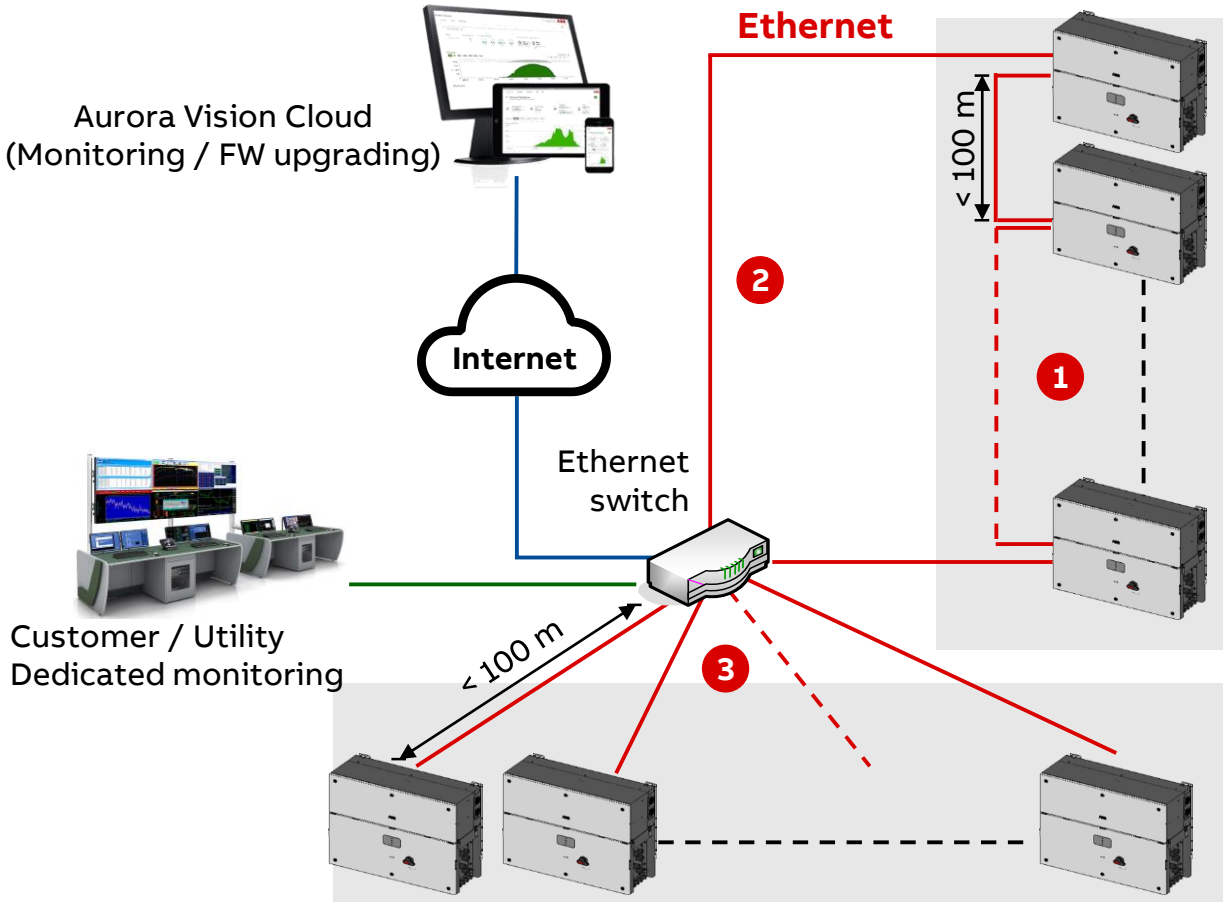
COMMUNICATION OVER ETHERNET

Standard Ethernet cable:

- Cable type: 100BaseTx, CAT5e with shielding or higher
- UV-resistant if used outdoor
- Type of plug: metallic shielded RJ-45

Three different line topologies:

1. Daisy chain over Ethernet cable (100 m @ maximum inverter—inverter)
2. Closed ring shaped layout for improving continuity of operations also in case of one inverter fault
3. Star layout (100 m @ maximum inverter—switch)



PVS-FAMILY

Installer friendly

‘Installer App’ to reduce plant installation costs

Simple and quick plant installation solution

Touch-free Inverter Commissioning

- Via WLAN Access Point connection
- App compatible with any Android smartphone and mobile device

Multiple Inverter Installation

- Commissioning of the entire plant/ cluster (up to 40 inverters over the same LAN)
- Optionally scan and track shipped inverters
- Smart app manages passcodes to minimize password issues
- Fast setup of single or multiple inverters: grid standard, input mode…

Solar integrated products

Product portfolio

Central inverters

1000 Vdc

PVS800

IS

MVP

up to 4.2MVA

1500 Vdc

PVS980

MWS

CS

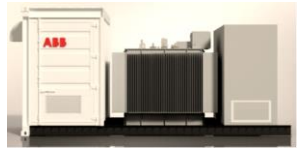
MVP

up to 4.6MVA

String inverters

PVS-100/120

MVS

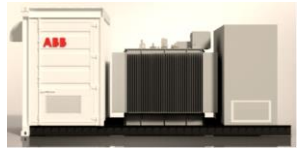


MVCS

up to 3.1MVA

PVS-175

MVS



MVCS

up to 6.7MVA

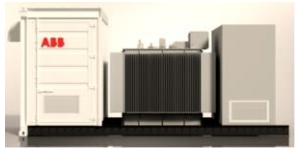
Solar integrated products

General features

- All made in Europe products
- EUR1 certificate available
- All ABB main components (except eventually transformer, depending on lead time required)
- Full overall warranty guaranteed by ABB
- Target lead time: 12-16 weeks EXW from PO for first batch, 5 stations per week thereafter
- All turn-key stations include a standard auxiliary board by default, which can be customized up to a certain point
- All turn-key stations include an auxiliary transformer of 10kVA by default, which can be upgraded to 20kVA or 30kVA
- All stations have C4 painting by default, which can be upgraded up to C5M painting (needed only if closer than <10km from sea)

Solar integrated products

Product ranges – PVS-100

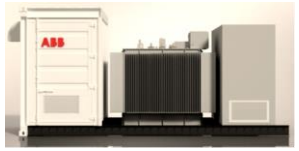


		Medium Voltage Station	Medium Voltage Compact Skid
		PVS-100-MVS	**PVS-100-MVCS**
Max power @ 40C	*8 inverters*	PVS-100-MVS-800	PVS-100-MVCS-800
	10 inverters	PVS-100-MVS-1000	PVS-100-MVCS-1000
	12 inverters	PVS-100-MVS-1200	PVS-100-MVCS-1200
	14 inverters	PVS-100-MVS-1400	PVS-100-MVCS-1400
	16 inverters	PVS-100-MVS-1600	PVS-100-MVCS-1600
	18 inverters	PVS-100-MVS-1800	PVS-100-MVCS-1800
	20 inverters	PVS-100-MVS-2000	PVS-100-MVCS-2000
	22 inverters	PVS-100-MVS-2200	PVS-100-MVCS-2200
	24 inverters	PVS-100-MVS-2400	PVS-100-MVCS-2400
	26 inverters	PVS-100-MVS-2600	PVS-100-MVCS-2600

Solar integrated products

Product ranges – PVS-120

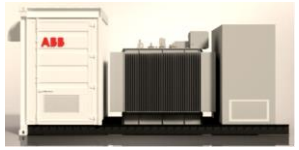
Max power @ 40C



	Medium Voltage Station	Medium Voltage Compact Skid
	PVS-120-MVS	**PVS-120-MVCS**
8 inverters	PVS-120-MVS-960	PVS-120-MVCS-960
10 inverters	PVS-120-MVS-1200	PVS-120-MVCS-1200
12 inverters	PVS-120-MVS-1440	PVS-120-MVCS-1440
14 inverters	PVS-120-MVS-1680	PVS-120-MVCS-1680
16 inverters	PVS-120-MVS-1920	PVS-120-MVCS-1920
18 inverters	PVS-120-MVS-2160	PVS-120-MVCS-2160
20 inverters	PVS-120-MVS-2400	PVS-120-MVCS-2400
22 inverters	PVS-120-MVS-2640	PVS-120-MVCS-2640
24 inverters	PVS-120-MVS-2880	PVS-120-MVCS-2880
26 inverters	PVS-120-MVS-3120	PVS-120-MVCS-3120

Solar integrated products

Product ranges – PVS-175



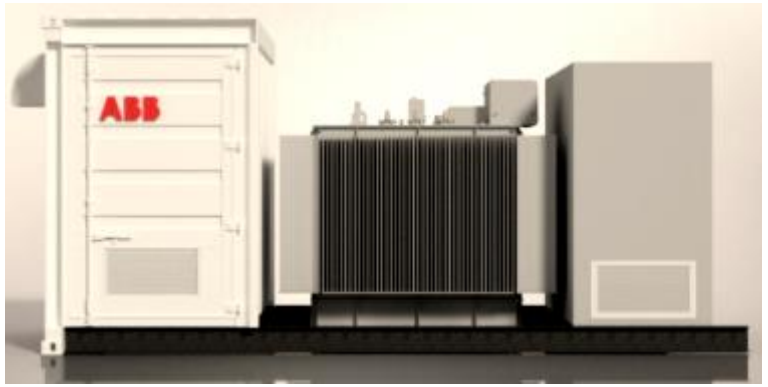
	Medium Voltage Station	Medium Voltage Compact Skid
	PVS-175-MVS	**PVS-175-MVCS**
10 inverters	PVS-175-MVS-1850	PVS-175-MVCS-1850
12 inverters	PVS-175-MVS-2220	PVS-175-MVCS-2220
14 inverters	PVS-175-MVS-2590	PVS-175-MVCS-2590
16 inverters	PVS-175-MVS-2960	PVS-175-MVCS-2960
18 inverters	PVS-175-MVS-3330	PVS-175-MVCS-3330
20 inverters	PVS-175-MVS-3700	PVS-175-MVCS-3700
22 inverters	PVS-175-MVS-4070	PVS-175-MVCS-4070
24 inverters	PVS-175-MVS-4440	PVS-175-MVCS-4440
26 inverters	PVS-175-MVS-4810	PVS-175-MVCS-4810
28 inverters	PVS-175-MVS-5180	PVS-175-MVCS-5180
30 inverters	PVS-175-MVS-5550	PVS-175-MVCS-5550
32 inverters	PVS-175-MVS-5920	PVS-175-MVCS-5920
34 inverters	PVS-175-MVS-6290	PVS-175-MVCS-6290
36 inverters	PVS-175-MVS-6660	PVS-175-MVCS-6660

Max power @ 30C

String Power Stations

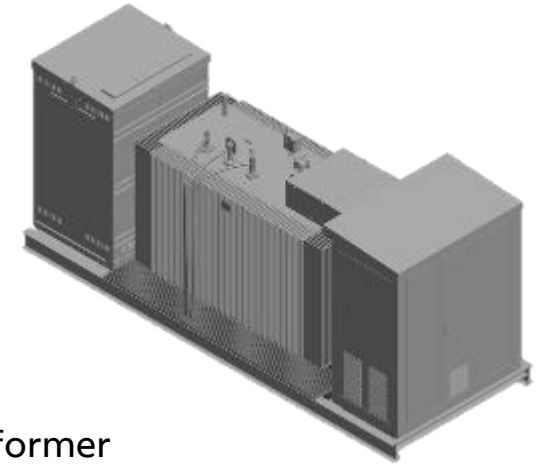
KEY BENEFITS

- ✓ Plug&play solution
- ✓ Very competitive price
- ✓ Transportability savings
- ✓ Compact and robust design
- ✓ IP54 & C4
- ✓ FAT attendance
- ✓ Flexibility → available for PVS100/120/175
- ✓ String Solution → More adaptability
  - Wide Power capacity
  - Great adaptability for PV plant configuration
- ✓ More space for customers personalization
- ✓ Less civil work needed per station



String Power Stations

KEY DIFFERENCES



- Oil Transformer
- Specific requirements for unloading
- Fits inside 20 HC container.
- Very limited space for additional services (UPS/ Communication Board)
- Easy access for O & M
- Less Expensive

- Dry Transformer
- More exposed during transportation
- 20-feet HC container based structure for cost efficient and easy transportation.
- Less limited space for additional services (UPS/ Communication Board)
- Controllable access

PVS800-57B

Central inverter, indoor – up to 2.08MW

Compact and easy-to-maintain central inverter for indoor installations

- Lower PV system costs
- High power density
- Easy to service
- All in one design
- ABB service with global support
- Maximized reliability

PVS980-58

Central inverter, outdoor - up to 5MVA

Reliability, efficiency and low maintenance for low LCOE

- Low levelized cost of energy (LCOE)
- Maximized reliability
- Lower PV systems cost
- For harsh environments
- ABB service with global support
- Long Lifetime

PVS980-58BC

Bi-directional converter, outdoor - up to 2.3MVA

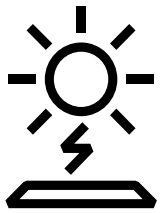
Lower system cost with high voltage batteries

- High total performance
- Maximized reliability
- Lower system cost
- For harsh environment
- ABB service with global support
- Long lifetime

The market segments where we play

From a kW all the way up to MWs

Fast and effective changes in a very dynamic market



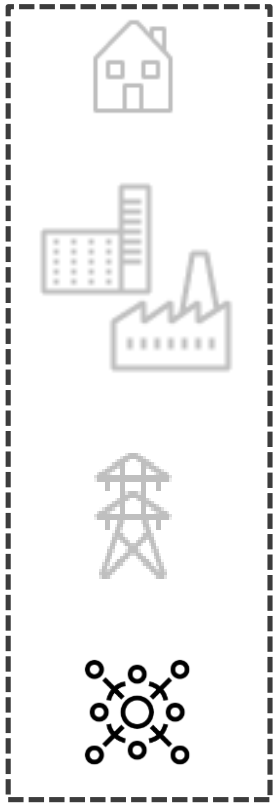
PG Solar

A wide offer with different **DC to AC** inverter technologies supported by Digital platforms

ABB Ability

DC

AC



Residential

Usually projects **below 10kW**

- All about rooftop, typically single phase, one or very few inverters
- High value to connectivity, user friendly

Commercial & Industrial

Between **10 to 5000kW**

- C&I roofs, all three phases, some or many inverters
- Flexibility, compactness and performances the keys

Utility

Above **5000kW**

- Massively ground mounted
- From LV to MV, always big and many units
- $/W, performances and O&M on top

Microgrid

On/Off-grid projects

- From kw up to MW
- Rural installations primarily in Emerging countries

MGS100

True three phases energy mix solution - 20/40/60kW

An integrated Microgrid system for reliable, sustainable power

- Multiple operating mode
- Integrated solution
- Reliable electricity access
- Quick & safe installation
- Easy scalable solution
- Monitor anywhere, anytime

MGS100

An integrated Microgrid system for reliable, sustainable power

Multiple operating mode

Supports **off-grid & On-grid,** night mode, and recovery Modes

Control system with **PLC** functionality

Simple to adjust through **HMI**

Quick and safe installation

Customizable **Plug & Play Solution,** factory pre-tested and fully pre-wired

All **input & output protection** are embedded

70% lesser installation/commissioning time

Integrated solution

All in one inclusive solutions

True **3 phase** solution

66% fewer components in single cabinet, constructed with ABB proven components.

Reliable electricity access

Seamlessly, can operate with multiple sources: **DG-Solar-Grid-Battery**

Operates with **100%** phase to phase imbalance continuously

Battery voltage range **504-576Vdc** for a high efficiency of the system

Monitor anywhere, anytime

System data can be monitored locally & remotely via connection to cloud platform

Remote connectivity via static **IP internet**

The system is **IoT ready**.

Able to configure as **100%** redundant system

Easy scalable solution

Capacity of Solar/Load can be increased by adding more inverters in parallel up to 1.6 MW

Compliant with all **Trio's family & PVS 100**

Number of independent MPPT range: **2-6**

Aurora Vision Plant Management Platform

Cloud based services for all applications

Remote Solar Plant Condition Monitoring

- Fleet Wide Visibility into Solar Power Plant Performance
- Solar Plant Condition Monitoring
- Basic Solar Plant Asset Tracking
- Advanced Energy Operations Reports
- Integrated ABB Service including Remote Firmware Update
- Trusted and Secure