Photovoltaics

Planning module

Efficiency is a matter of the right Planning.

Vaillant Comfort for my home

Introduction

The energy that is produced by the sun in one day can cover the entire energy demand of the human race for 180 years.

And the best thing is that this inexhaustible and free source of energy can be exploited very easily.

With a photovoltaic system, your customers can generate their own electricity and therefore acquire part of this energy for domestic appliances, heating and domestic hot water, thus becoming less dependent on increasing electricity prices.

auroPOWER is the reliable Vaillant photovoltaic system with components with the best of brand quality that are perfectly harmonised with each other.

From photovoltaic modules, inverters and fastening systems, through to battery banks.

Reliable quality from a single source offers you and your customers the following benefits:

- The complete photovoltaic system from a single source
- System components with the best of brand quality that are harmonised with each other
- Long-term guarantees for photovoltaic modules and inverters
- Intelligent energy management for maximum yield

Whether a project for constructing a new building or a building renovation/modernisation measure is planned, a large amount of data must be recorded and evaluated in order to implement an efficient solution for exploiting solar energy.

You can find planning information for the subsequent detailed installation planning in this document.

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1. Basic principles

For five billion years, the sun has been providing the earth with energy and it will continue to do so for many years to come. And what makes more sense than to make use of this energy?

1.1 The power of the sun

Fig. 1: The power of the sun

Just 8 minutes of sunlight on the surface of the earth corresponds to the current annual energy consumption of the entire world. Compared with this potential, the available resources of fossil and atomic energy sources are low.

1.1.1 Radiation values

The radiated power of the sun that is received at ground level is known as global radiation. In relation to the long-term average and depending on the location, the annual solar radiation volume varies along a horizontal plane between 950 kWh/m² and 1200 kWh/m² in Germany, for example.

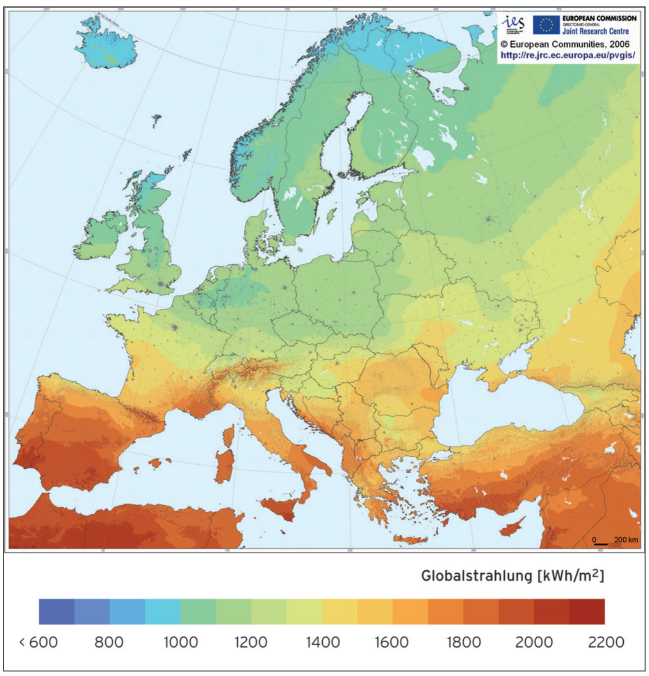

Fig. 2: Global radiation in Europe – average yearly totals in kWh/m²

The level of direct and diffuse radiation is highly dependent on the season and local weather conditions. Diffuse radiation is caused by scattering, reflection and refraction of clouds and particles in the air. This can also be used.

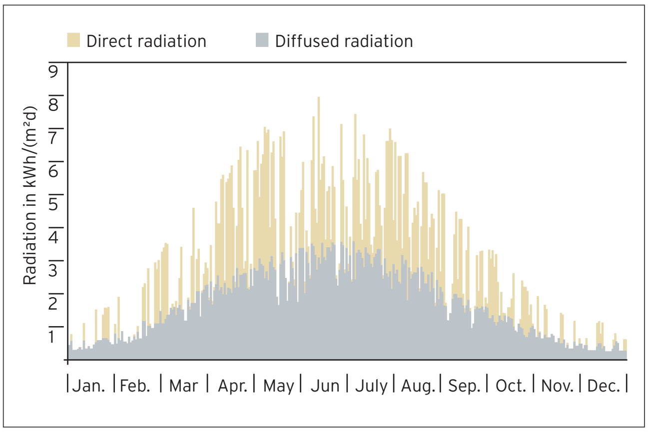

Fig. 3: Seasonal trends for global radiation in Berlin

If a cloudy day produces a proportion of diffuse radiation above 80%, 300 W/m² of solar radiation can still be measured.

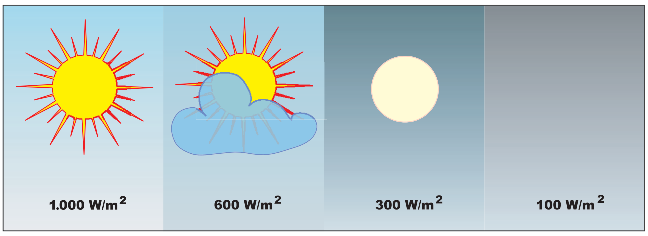

Fig. 4: Direct and diffuse radiation can be used

The average radiation at a particular location can be read on solar radiation maps. For a rough calculation of the annual yield, 1000 kWh/m²a (horizontal) is usually assumed.

1.2 Yield from a photovoltaic (PV) installation

The annual yield of a PV installation is primarily dependent on the following factors:

- Solar radiation at the installation site
- Incline β [beta] and alignment α [alpha] of the modules
- Potential shading
- Technical properties of the PV components, in particular the PV modules and PV inverter

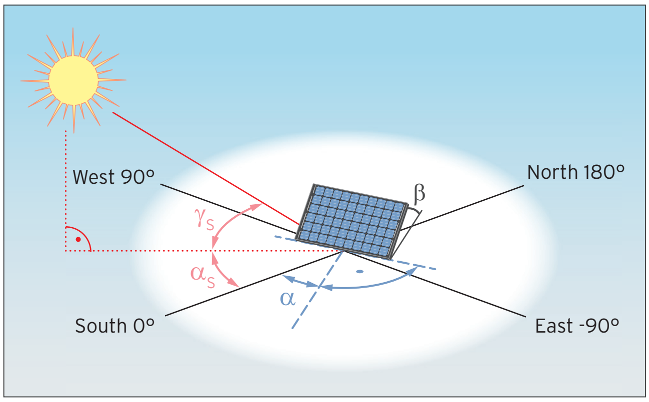

Fig. 5: Angle labels in the solar technology

αS Solar azimuth
γS Sun elevation angle
α Azimuth of the PV generator
ο Incline of the PV generator

1.3 Orientation and incline of the generator

A PV installation with a generator nominal output of 3 kWp generates between 2000 kWh and 3000 kWh of environmentally friendly PV electricity each year depending on the location, orientation and incline. This corresponds to approx. 100% of the power requirement for a three-person household and guarantees a CO_2 saving of up to 2000 kg.

The highest yields are achieved in Germany with an orientation to the south and an incline angle of the modules of 30 to 45°.

To ensure that dirt and contamination is washed away by the rain, the generator must have an incline of at least 10°.

The percentage irradiation for a generator that has not been oriented optimally can be found in the following illustration.

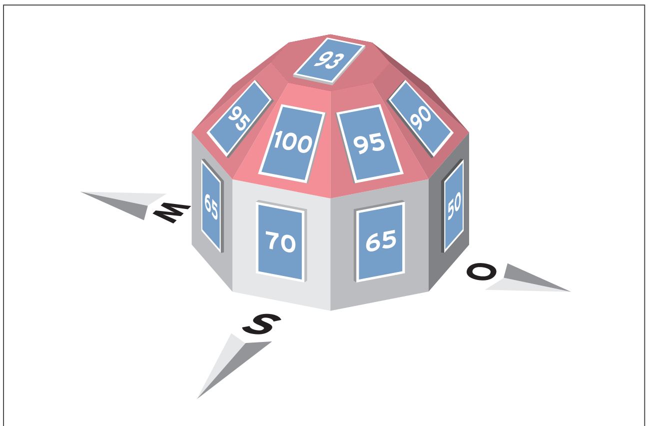

Fig. 6: Percentage deviation of the irradiation from the optimum orientation

The further the generator is oriented to the east or west, the more favourable it becomes to have a steeper incline angle. Since with east or west roofs, in addition to the reduced irradiation, higher reflections occur on the glass pane, the expected yields fall significantly below the deviations in irradiation data shown now and then.

Extremely high losses of earnings may be generated by shadows being case by surrounding objects. Relatively small shadow lines, such as those caused by antennas, power and telephone lines, lightning conductors, etc., must be taken into consideration during the planning.

Note that trees in the garden may grow over the next 25 years or that neighbouring land may be built on.

Antennas that cast a shadow may be fitted on the north roof; on new builds, the chimney or satellite system belongs on the north roof from the outset. If shadows that cannot be eliminated remain, the arrangement and switching of the modules on the roof must be designed accordingly (see more detailed information in the section on installation planning).

In difficult cases, simulation programmes and an indicator of the sun's orbit can be used to carry out shading analyses, which use the sun's orbit curve to display the shading for different times of the day and year.

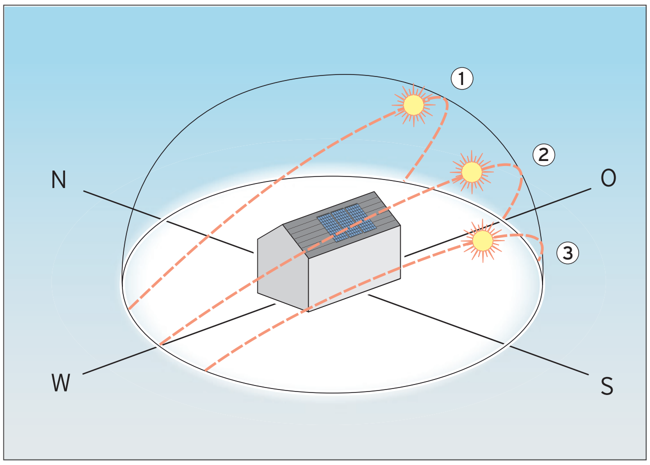

Fig. 7: Sun elevation over the course of the seasons

1 Summer solstice
2 Autumn/spring
3 Winter solstice

1.3.1 Generator surfaces with different orientations

As soon as the PV modules are divided over roof areas with different alignments, each sub-generator must be connected to its own MPP tracker, which is part of the inverter.

The MPP tracker in the inverter ensures that the output of the modules that are combined to form strings is always optimally adapted to the relevant radiation and temperature status.

This is the only way to optimally adapt to the various irradiation conditions.

1.4 PV installation systems and applications

The main applications for PV systems are:

- Installations for customers connected to the „public grid“ (grid-connected systems).
- Off-grid installations with electrical storage systems.
- Large PV installations directly connected to the medium-voltage grid.

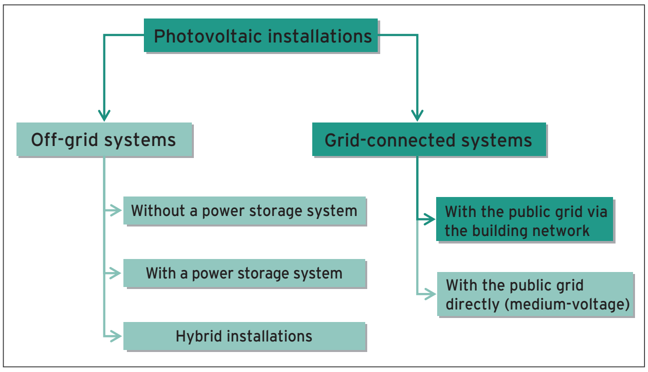

Fig. 8: Photovoltaic installations at a glance

1.4.1 Off-grid installations with electrical storage systems.

Off-grid systems are used wherever it is not possible, cost-effective or desirable to supply power via the power grid.

Areas of application for PV off-grid systems are:

- Small applications, such as battery chargers, calculators, garden lamps, etc.
- Mobile systems for cars, caravans, boats, etc.
- Outlying buildings, such as chalets, gazebos, weekend and holiday homes (with or without an alternating current circuit)
- Small off-grid systems, such as emergency phones, parking meters, buoys, etc.
- Photovoltaic pump systems for supplying potable water or for irrigation
- Electrification of buildings or villages (e.g. in developing countries)

A typical off-grid system consists of the following main components:

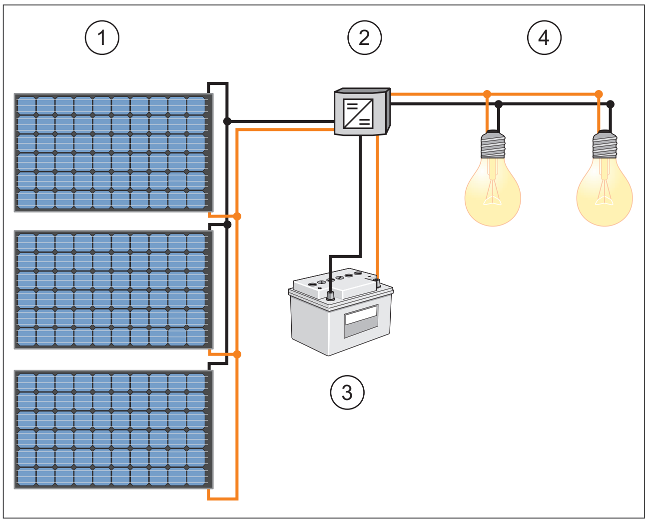

Fig. 9: Photovoltaic island system

1 PV generator
2 Inverter
3 Battery
4 Consumer

1.4.2 Grid-connected installations

The main feature of grid-connected PV installations, is that they are connected to the public power supply network. A battery bank can be used to temporarily store part of the excess electrical energy.

A grid-connected PV installation consists of the following main components:

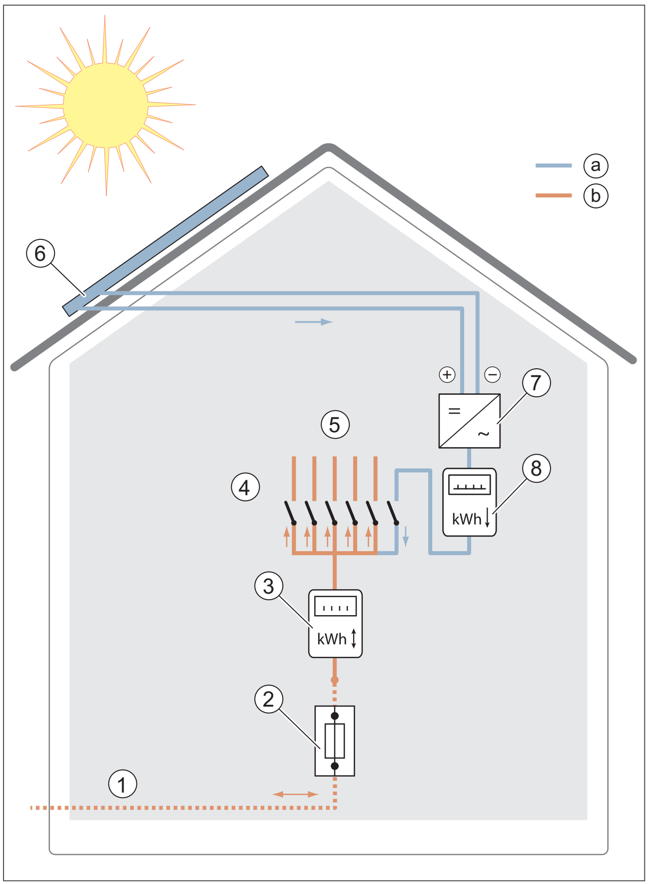

Fig. 10: Main components of a grid-connected photovoltaic installation

1 Energy supply company network 230/400 V
2 Utility connection box
3 Meter for current draw and feed-in
4 Distribution/fuse box
5 Consumer units
6 Photovoltaic generator
7 Grid feed-in appliances/inverters
8 Photovoltaic feed-in meter
a PV current
b PV current and network current mixed

1.5 Photovoltaic components

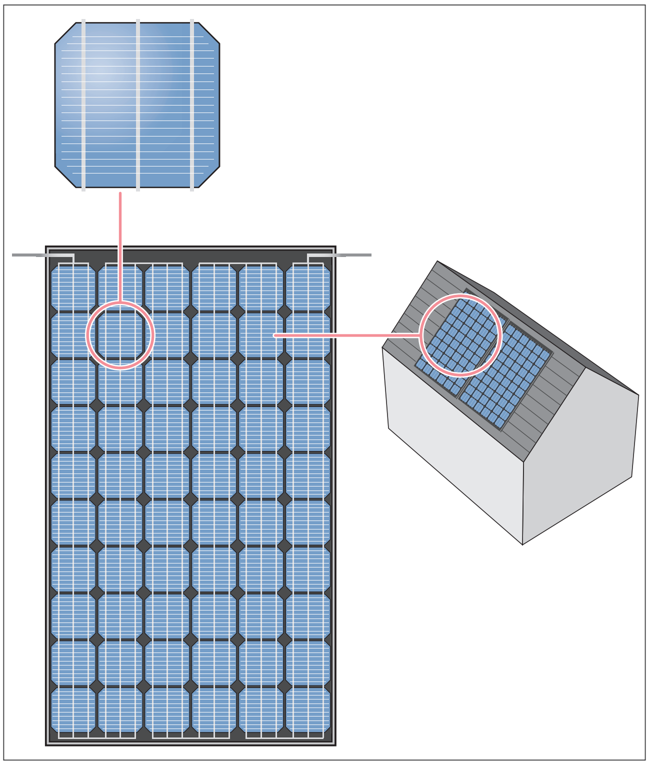

Fig. 11: Photovoltaic components

Sunlight is converted into electric power within a photovoltaic cell. Individual photovoltaic cells are switched in a row and combined to form a module string. A photovoltaic module, in turn, consists of several strings of photovoltaic cells. In addition, a junction box with bypass diodes is attached to the rear of the photovoltaic modules.

Electrically connecting multiple photovoltaic modules produces a photovoltaic generator. In the process, PV modules can be linked in a series circuit, parallel switching or a combination of both wiring designs. The connection must match the inverter that is used because it is not possible to connect multiple module strings to each inverter.

In order to connect the individual PV modules to each other, each Vaillant PV module comes with a direct current cable with a plug and coupling. This ensures that the connections between the individual PV modules are secure.

The generator field has an all-pole disconnect switch, safeguarded by the DC isolator integrated in the inverter. This is guaranteed by the DC main switch that is integrated into the Vaillant inverter. No separate generator connection box is required for connecting the Vaillant PV modules.

1.5.1 The photovoltaic cell in detail – design and mode of operation

Photovoltaic cells are primarily built from ultra-pure silicon, which is used in the electronics sector for semiconductor elements. The raw material used is quartz sand, which is available in abundance.

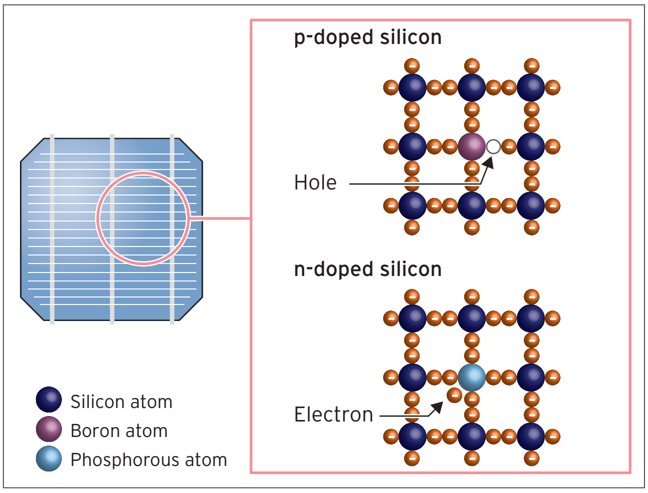

Fig. 12: Charging potential of dirty silicon atoms

The silicon atoms form a stable crystal lattice. The addition of targeted impurities (doping) allows various charge potentials to be created. The layer facing the sunlight is negatively doped with phosphorus (resulting in an excess of electrons), whereas the layer of silicon beneath it is positively doped through the targeted addition of boron atoms (resulting in an electron vacancy).

At the boundary layer, this produces an electrical field which is polarised against the two doped layers, which in turn separates the charge released by the sunlight. When light strikes the cell, electrical energy potential is created (electrical voltage).

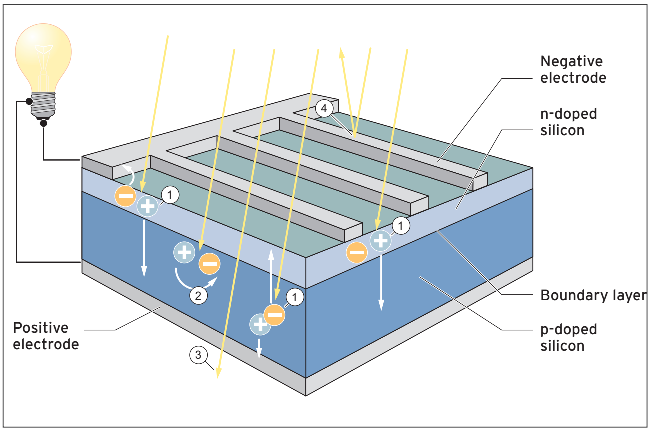

Fig. 13: Design and mode of operation of a crystalline photovoltaic cell

1 Charge separation
2 Recombination
3 Unused photon energy (for example, from transmission)
4 Reflection and shading by the front contacts

In order for a photovoltaic cell to be able to produce electrical energy, it must be exposed to sunlight (photons). Photons are the „building blocks" of electromagnetic radiation, a bit like „light particles". When photons hit the cell, the resultant energy input allows electrons to move more freely and return to the n-type area. At the same time, an electron vacancy develops in the p-type area again. This process is known as the photovoltaic effect.

The electrons then move to the contacts mounted on the cell, creating an electrical voltage across the cell.

If the cell is not loaded, this voltage is also called the no-load voltage.

If the electrical circuit is then closed, a direct current flows through it.

1.5.2 Types of photovoltaic cell

The two most common types of cell are monocrystalline silicon cells and polycrystalline silicon cells.

The following overview shows the different cell types and their efficiencies for 1 kWp output.

Types of photovoltaic cell

Cell material	Module efficiency	Cell size
Monocrystalline	15 - 20 %	5-7 m²
Polycrystalline	14 - 18 %	6-7 m²
Thin layer: Copper indium diselenide (CIS)	10 - 12 %	8-10 m²
Cadmium telluride (CdTe)	10 - 14 %	7-10 m²
Amorphous silicon (a-Si)	6 - 10 %	10-17 m²

Monocrystalline photovoltaic cells

The Czochralski process involves dipping a crystal seed into molten silicon, which is then slowly withdrawn from the molten material while simultaneously being rotated. This produces completely regular individual crystals with a diameter of approx. 30 cm and a length of several metres. The ingots are cut into approx. 0.18–0.22 mm-thick slices (wafers). Starting with the p-type dosed wafers, a thin n-type layer is created using phosphorus diffusion. After the contact layer has been applied to the back of the wafer, current draw lines and an anti-reflective layer are applied to the front. The anti-reflective layer gives the cells, which are actually silver-grey in colour, a bluish-black shine.

Polycrystalline photovoltaic cells

In the ingot casting process, silicon is heated in a vacuum and cast in a mould. As it cools, lots of tiny crystals appear (in a frost-like pattern). The silicon ingots are sawn into rods and then wafers, which already have a rectangular shape. An n-type layer, a contact layer on the back and current draw lines and an anti-reflective layer on the front are then applied as before.

1.5.3 Important characteristics of the photovoltaic modules

When light strikes the cell, electrical energy potential is created (electrical voltage). Metallic contacts are attached to the front and rear of the cells. If the electrical circuit between both poles is closed by a consumer, a current flows.

The power and, therefore, the electrical output of a PV cell is directly dependent on the irradiance. The PV cells therefore supply the most energy when there is direct sunshine. With diffuse light, only a low output can be delivered.

Furthermore, the efficiency of the photovoltaic cell largely depends on the temperature. The lower the cell temperature, the higher the equivalent surface area in the current/voltage curve, which corresponds to the maximum possible output as the product of the voltage and amperage.

In order to optimise the energy yield, the inverter of a PV system attempts to set the MPP (maximum power point), which is the optimum ratio of current and voltage under the current radiation and cell temperature.

The peak output **Wp = Watt peak** of a photovoltaic cell is determined under standard test conditions (**STC = Standard Test Conditions**). The standard test conditions were introduced in order to be able to compare photovoltaic cells or even modules with each other.

The standard test conditions are defined as follows in the standards DIN EN 60904 and IEC 60904:

- Radiation E = 1000 W/m²
- Cell temperature 25 °C (±2 °C)
- Defined light spectrum (in accordance with IEC 60904-3)

The nominal output for each photovoltaic module contains the additional note „Wp under standard test conditions“.

In addition, the **NOCT** value is specified. The abbreviation „NOCT“ stands for **Normal Operating Cell Temperature**.

This means that the photovoltaic cell is tested in normal operating mode.

Unlike with the standard test conditions, the following average NOCT values are used:

Average NOCT values

Wind speed	1 m/s Lower range of wind strength (3.6 km/h)
Irradiance	800 W/m² The solar irradiation on a summer's day in Central Europe is around 700 W/m²
Air mass (abbr. AM)	1.5 The radiance from when the sun is at a moderate morning/afternoon angle (48.2°)
Environmental temperature	20 °C
Cell temperature	46 (± 2)°C

Photovoltaic installations that bear the RAL-GZ 966 quality mark have been NOCT-tested.

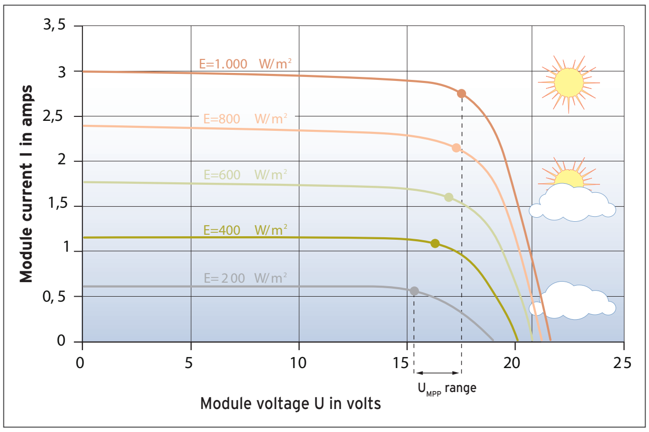

Fig. 14: Depending on the current/voltage characteristic of the radiation

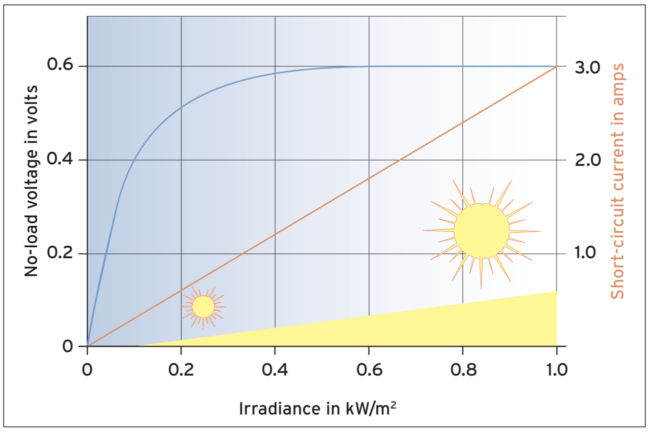

Fig. 15: No-load voltage and short-circuit current depending on the radiation

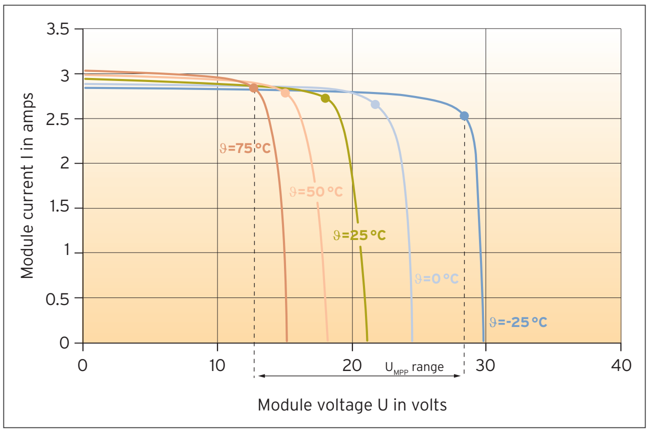

Fig. 16: Temperature dependence of the current/voltage characteristic

1.5.4 DC cable

To guarantee electrical safety throughout the entire service life of the installation, the direct current cabling should be particularly durable and resilient.

Requirements for the DC cable:

- Mechanical strength,
- UV-, ozone- and weather-resistance,
- Temperature resistance,
- Design temperature on the roof: 70 °C,
- Fast and safe installation.

For routing that is safe from earth faults and short circuits, the positive pole and negative pole are used as separate, single-core cables with double insulation.

All Vaillant PV modules and DC cables are equipped with multi-contact plugs that are safe to touch and protected against polarity reversal, and that allow for tool-free installation and exclude faults in the cabling. The cables are therefore also not labelled in red or blue.

UV-resistant tools must be used to secure the lines.

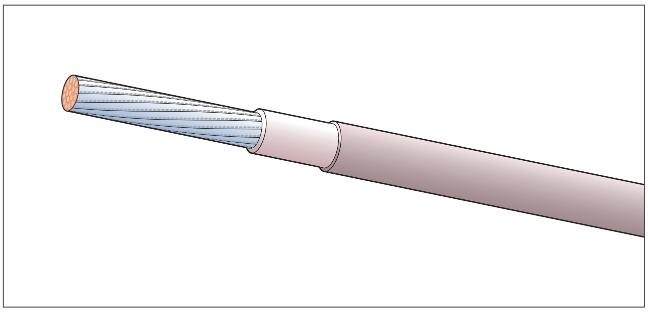

Fig. 17: Special single-core cable with double insulation

1.6 The inverter

The inverter converts the direct current that is supplied by the PV generator into single-phase alternating current with 230 V mains voltage or, for larger installations, into three-phase current with 400 V mains voltage.

Inverters are offered in many performance categories as central inverters, string and/or multi-string inverters or as module inverters.

With a central inverter, all PV modules are connected to an inverter.

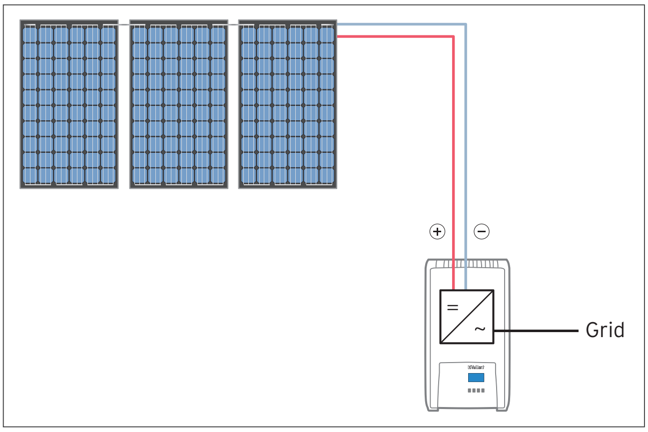

Fig. 18: PV installation with central inverter

With many installations, it is possible and/or necessary to divide the generator over several inverters; for example, for larger generator power levels, for partial shading, deviating orientations or inclines within the generator.

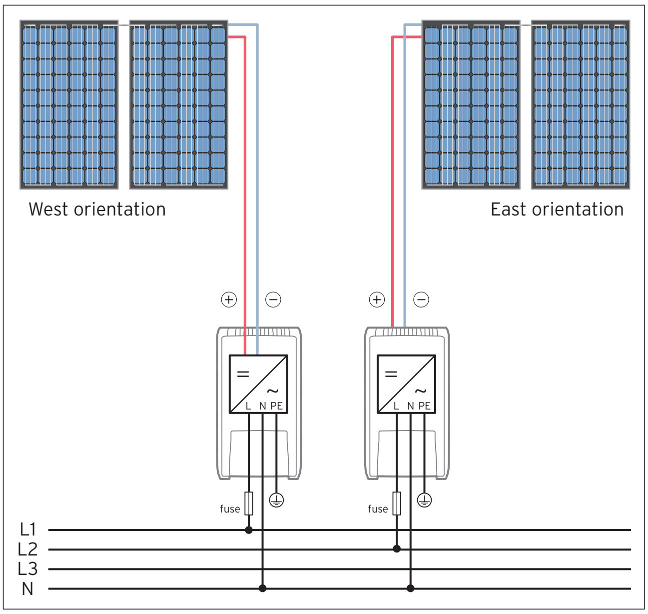

Fig. 19: PV installation with sub-generator inverter

1.6.1 MPP control in the multi-string concept

Using string inverters may lead to significant energy losses in the case of installations that are in the shade or installations that have different sub-generator alignments.

To reduce these losses, similarly oriented modules can be combined to form module strings. Each module string and/or sub-generator is controlled by a separate MPP control. This concept is known as the multi-string concept.

The advantage of this concept is that you can use only one inverter for many differently aligned sub-generators.

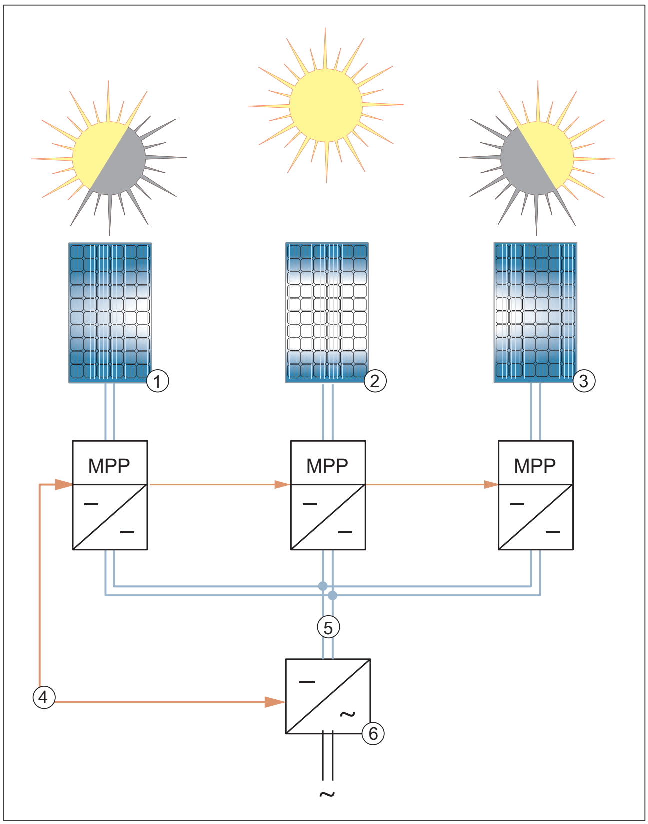

Fig. 20: Multi-string inverter

1 PV sub-generator, west
2 PV sub-generator, south
3 PV sub-generator, east
4 Control process, control and protection function unit
5 DC bus
6 Common inverter

1.6.2 MPP control in the DC bus concept

With this concept, the inverter is disconnected from the MPP controls. A separate MPP control is set in each module string or upstream of each module. All of the module strings and/or modules are connected to the central inverter unit via the DC bus line.

The MPP control adapts its output voltage to the DC bus voltage. This means that module strings and/or modules with different voltages and currents, different cell technologies (polycrystalline, monocrystalline, thin layer, etc.), module temperatures, module arrangements and orientations as well as shading conditions can be connected without corresponding mismatch losses occurring.

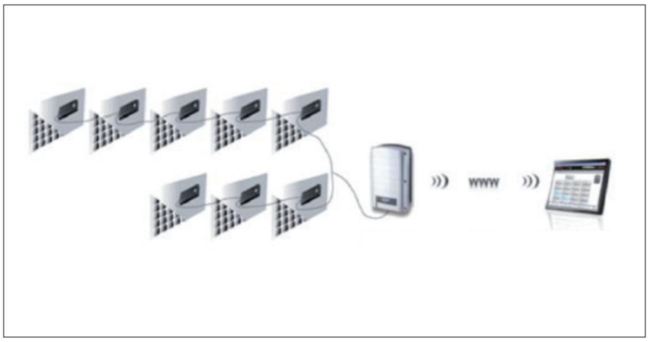

Fig. 21: Separate MPP control connected to the inverter via a DC bus line for each module (SolarEdge)

1.7 The battery bank

1.7.1 Functionality of the battery bank

The battery bank allows for intelligent energy management in the building.

You can use the battery bank to store excessive electrical energy that is generated. This stored energy can be used to supply electrical consumers, if required.

In order to optimise energy consumption and minimise the outsourcing of electrical energy, the energy flows in the house are recorded and controlled. To do this, radio-controlled outlets are used to switch specific electrical consumers on or off.

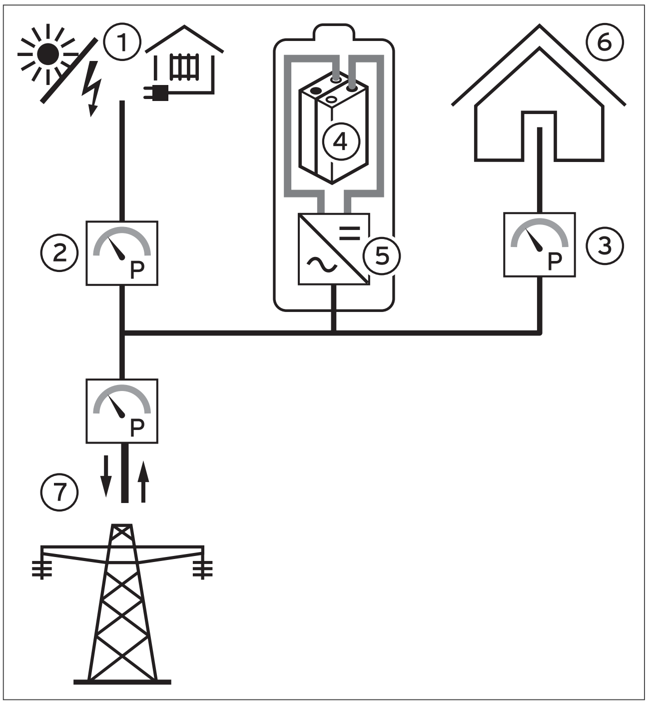

Fig. 22: Operating principle of the battery bank

The power that is created by a combined heat and power system or a PV installation (1) is recorded by a measuring instrument (2). Another measuring instrument (3) measures the current consumption in the house.

If the self-generated electrical energy is greater than the energy that is required by the consumers in the house, there is an energy excess. The excess energy is stored.

To do this, the battery inverter (5) converts the energy in the battery bank into direct current. The generated energy is then stored in the batteries (4).

If the current consumption is greater than the self-generated electrical energy, electrical energy is released by the storage system.

Before it is released to electrical consumers in the house (6), the stored energy is converted back into alternating current using the battery inverter (5).

A bidirectional meter (7) ensures that the energy that is procured from the public power grid and the energy volume that is fed into the public power grid is calculated.

1.7.2 Lithium-ion batteries

Lithium ion battery is a generic term for batteries that are based on lithium connections.

Lithium iron phosphate batteries ($LiFePO_4$) are used frequently in building technology because these stand out thanks to their great temperature stability, long service life and high charge and discharge flows.

Fig. 23: Lithium-ion battery

1.8 System concepts

The following illustrations show typical load profiles for a house.

1.8.1 Load profile without power generation system

The graphic shows a typical load profile for a house without a power generation system (e.g. CHP system or PV installation). The entire required electrical energy is covered by the public network.

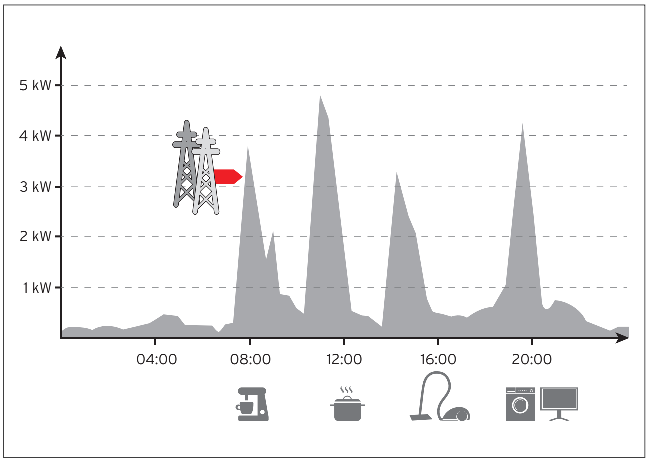

Fig. 24: Load profile without power generation system

1.8.2 Load profile with PV installation

Thanks to the yield of an existing PV installation, the electrical energy that is covered by the public network is significantly reduced.

The own consumption rate for a house without intelligent energy management and electricity storage is therefore approx. 30%. The remaining energy that is generated and that cannot be used by the owner is fed into the network.

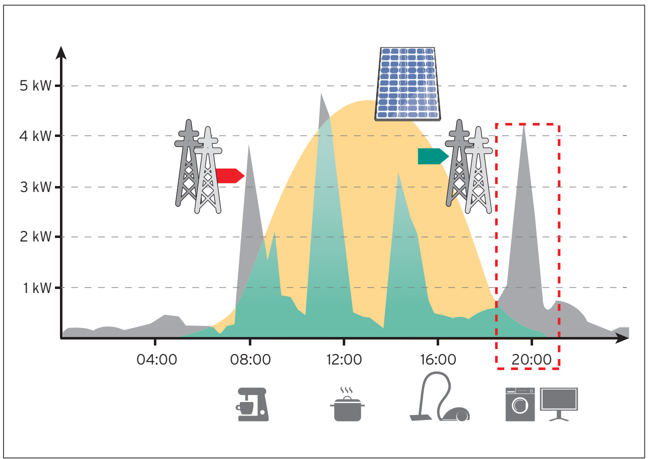

Fig. 25: Load profile with PV installation

The peak load in the evening is caused by a washing machine, for example, that has been manually switched on.

1.8.3 Load profile with PV installation and energy management

By postponing the resulting peak times to the yield times, using appropriate energy management, less energy is fed into the network. The own consumption rate can be increased to approx. 45%.

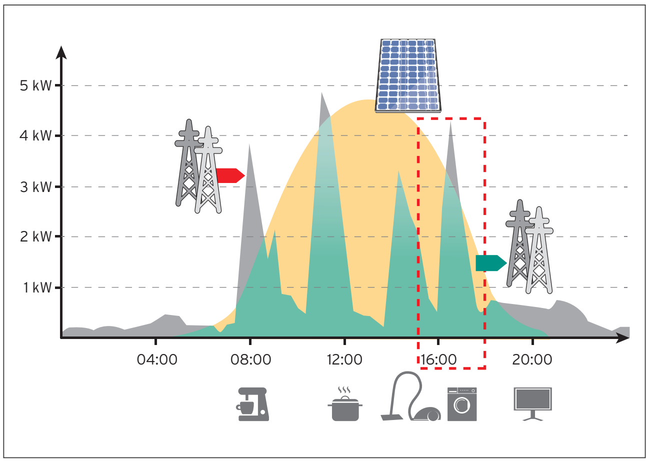

Fig. 26: Load profile with PV installation and energy management

In this case, the peak load was moved to the afternoon. Due to the automatic control provided by the energy management, the time at which the washing machine is operated is moved to a time at which PV energy is available. As a result, the own consumption of the PV energy and the costs for energy that is taken from the grid are reduced.

1.8.4 Load profile with PV installation and battery bank

In addition, the own consumption rate is increased by a battery bank system with intelligent battery-charging management. On the one hand, the intelligent battery-charging management ensures that sufficient capacity is available to store the yield peaks at midday. On the other hand, it ensures that the storage system is fully charged by the evening so that sufficient energy is available for night-time. The own consumption rate for such an installation may be as much as 85%.

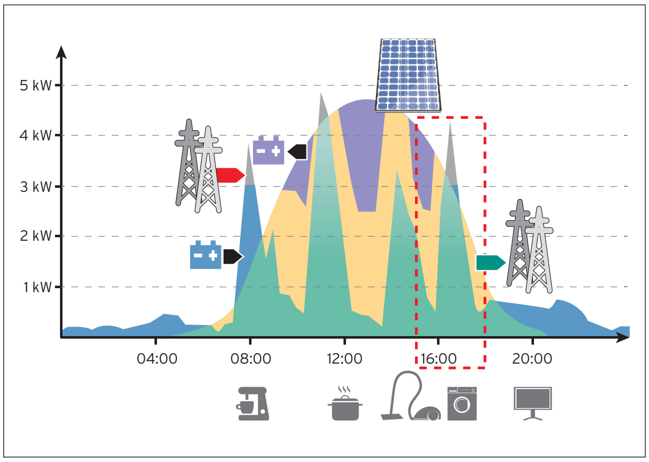

Fig. 27: Load profile with PV installation and battery bank

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2. Legal framework

Anyone planning a construction project or an extensive renovation must observe the legal framework. The following Germany-wide energy-saving regulations are particularly important here.

2.1 Energy Saving Ordinance (EnEV 2014/2016)

The first version of the EnEV has been in force since February 2002. To implement the EU directive on the energy performance of buildings, a new version was created and this came into force on 1st October 2009.

Since 1st January 2016, even stricter efficiency requirements apply for new builds.

The Energy Saving Ordinance (EnEV) aims to comply with the Kyoto Protocol from 1997 and the German government's aim, which resulted from Kyoto, to have a building stock which is almost climate-neutral by 2050.

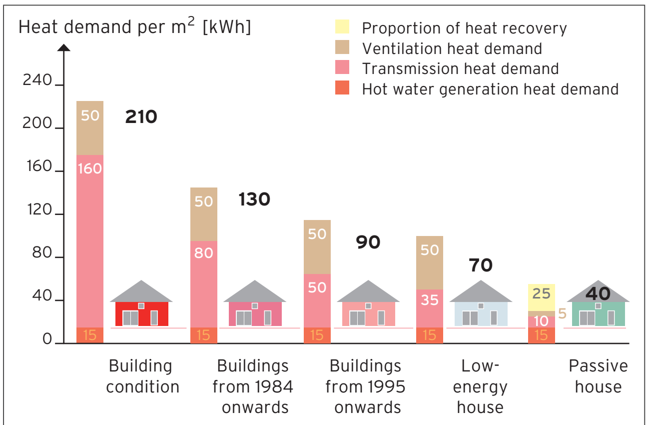


Fig. 28: Developing the heat demand

In contrast to the previous energy-saving ordinance, the calculation now includes not only the heat demand but also the energy that is required for room ventilation and for potable water heating. The primary energy requirement for a house is determined from the total number of such parameters.

By taking heat recovery into account as a replacement measure, using controlled domestic ventilation with heat recovery has a positive effect on a building's primary energy requirement and facilitates the Energy Saving Ordinance requirement.

EnEV 2014/2016 regulates the standards for the maximum permissible annual primary energy requirement for buildings at the time of the building application.

The thermal insulation requirements for the building shell have been made stricter.

The amendments to EnEV 2014/2016 mean that the requirements for new builds, existing buildings and the energy performance certificate are more precise, simplified and stricter.

Non-residential buildings with rooms that are more than four metres high do not have to comply with these stricter regulations if they are heated using decentralised fan heating or radiation heating systems.

2.2 German Renewable Energy Act (EEG)

The German Renewable Energy Act (EEG) is the central funding instrument for expanding power supply using wind, sun, etc. The objective is to increase the proportion of renewable energies in the German power supply to at least 80 per cent by 2050.

With the EEG, the grid operator is obligated to give priority to electricity generated by renewable energies and, usually, to remunerate for this at a rate considerably higher than the market price. For this purpose, the law regulates the power supply of installations in which electricity is recovered from renewable energies. It also determines which remuneration the system operator receives for the electricity that is generated per kilowatt hour within a certain time period. The remuneration rates that are determined and the relevant changes are contained in the act (see http://www.bmwi.de/DE/Themen/Energie/Erneuerbare-Energien/eeg-2014.html).

2.3 Framework in new builds

If you are planning a new building, it must be an energy-efficient building in accordance with the EnEV (German Energy Saving Ordinance).

With EnEV 2014/2016, the German federal government has laid the foundations for implementing the European directive for energy efficiency in buildings. This states that, as of 2021, only ultra-low-energy new builds may be constructed within the EU. Public buildings must comply with this standard as of 2019.

EnEV 2014/2016 specifies new, stricter limits for the maximum permissible annual primary energy requirement in new builds. As always, this is compared with the maximum permissible primary energy requirement of prototype buildings but, as of January 2016, it must be 25% below the old value for the reference building.

The primary energy factor for electricity has been 1.8 since 2016.

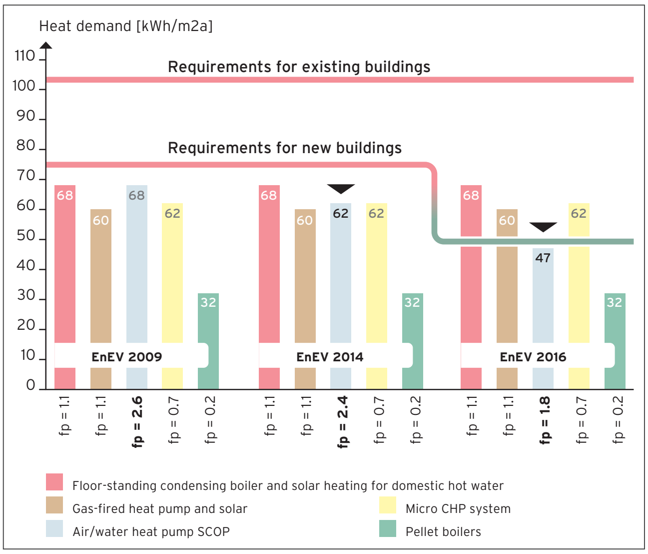


Fig. 29: Requirements for new builds and existing buildings

2.3.1 Thermal insulation requirements

The heat loss through the building shell of the new residential building must not be higher than what is specified in EnEV 2014/2016. The following table lists these binding maximum values.

Thermal insulation requirements

Building type/residential building		Maximum values for the specific transmission heat loss (H'T) in W/(m² · K)
Free-standing	With A_N* ≤ 350 m²	0.40
	With A_N* > 350 m²	0.50
Semi-detached**		0.45
Other types		0.65
Extensions and expansions in accordance with Section 9 Paragraph 5		0.65

* A_N - usable area of the residential building
** A residential building is semi-detached if a proportion of 80% or more of the vertical surfaces of this building, which are oriented towards a point on the compass, adjoins another residential building or non-residential building that has a target room temperature of at least 19 °C. Source: EnEV 2014, Appendix 1 (requirements for residential buildings), www.bundesgesetzblatt.de

2.3.2 EnEV-easy for non-cooled residential buildings

The revised EnEV also makes a number of simplifications. EnEV certification for new, non-cooled residential buildings is no longer necessary if they comply with certain specifications regarding fixtures and fittings.

These specifications relate to the size, shape, alignment and leak-tightness of the building, to the prevention of thermal bridges, and the proportion of the exterior when compared to the entire heat transfer surface. Holiday and weekend homes are also exempt from EnEV certification if they are mainly used in spring and summer and their energy demand is less than 25% of the energy demand across an entire year.

2.3.3 Counting power from renewable energies

Counting power from renewable energies is already regulated by EnEV 2009. This power must be deducted from the final energy requirement of the new building if it is generated in or on the building and is used as the main energy source there. The corresponding calculation procedure is now provided by the revised EnEV. Since May 2014, experts have determined the power requirement as a monthly value using DIN V 18599; in the case of power from wind energy, this is determined based on DIN V 18599, Part 10.

2.4 Energy performance certificate

The energy performance certificate helps increase the energy efficiency of buildings by making their energy performance clear to owners, purchasers and tenants. In comparison to the EnEV (Energy Saving Ordinance) 2009, legislators have changed EnEV 2014/2016 as follows.

The span of the sliding bar has been significantly reduced – from over 400 kWh/(m² a) to a maximum of over 250 kWh/(m² a).

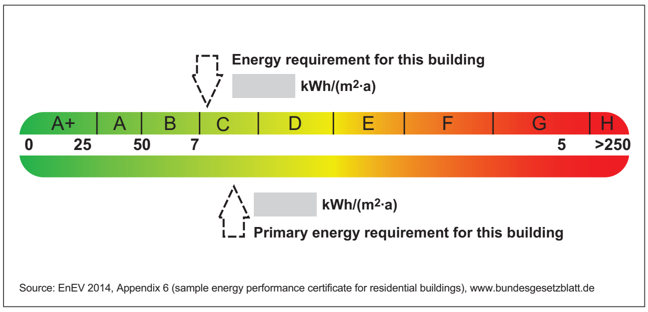


Fig. 30: Sliding bar with energy efficiency classes

Recommendations for modernisation are also integrated into this as part of the energy performance certificate. Appendix 10 of the EnEV now documents the efficiency classes for residential buildings.

Energy performance certificate

Energy efficiency class	Final energy [kWh/(m² a)]
A+	‹ 30
A	‹ 50
B	‹75
C	‹ 100
D	‹130
E	‹160
F	‹200
G	‹250
H	›250

2.5 Subsidy programmes checked?

New installations or systems can be subsidised by the government, federal states, municipalities and energy suppliers. The size of the subsidy depends on the location of the building, the type of construction project and the time of the application.

When using solar thermal energy, heat pumps, biomass (pellet boilers) or a CHP system, your customers can take advantage of numerous subsidies from the government, federal states, municipalities and energy suppliers.

2.5.1 Do you require help with the numerous different subsidies?

Vaillant supports their expert partners when seeking subsidies. On Vaillant's website, you can use the subsidy search to look for all subsidy options at a federal and state level, as well as all special regional programmes for your location and your project.

You can find the latest information here:

http://www.vai.vg/foerdermittelsuche

2.6 Regulations, directives and standards

When planning, setting up and installing a photovoltaic installation and/or the components (e.g. modules and inverters), you must comply with the applicable standards and directives.

An overview of the most important standards and directives:

- DIN VDE 0100-712: October 2016
- (Or the harmonisation document HD 60364-7-712) „Low-voltage electrical installations – Part 7-712 Requirements for special installations or locations – Photovoltaic (PV) systems."
- DIN EN 62446-1: Dec. 2016 (VDE 0126-23)
- (Or IEC 62446-1:2016) „Photovoltaic (PV) systems – requirements for testing, documentation and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection."
- DIN EN 62305-3 Supplement 5: Feb 2014
- „Protection against lightning – Part 3: Physical damage to structures and life hazard; Supplement 5: Lightning and overvoltage protection for photovoltaic power supply systems."
- VDI Directive VDI 6012
- „Regenerative and local energy systems for buildings. Fundamentals, securing solar modules and collector on buildings."
- VDE AR-N 4105
- „Power generation systems connected to the low-voltage distribution network – Technical minimum requirements for the connection to and parallel operation with low-voltage distribution networks."
- DIN VDE 0105-100 (VDE 0105-100): 2015-10
- „Operation of electrical installations Part 100: General requirements"
- DIN VDE 0298-4 (VDE 0298-4): 2013-06

- „Application of cables and flexible cords in power installations, Part 4: Recommended current-carrying capacity for sheathed and non-sheathed cables for fixed wirings in buildings and for flexible cables and cords“

In principle, photovoltaic installations are electrical installations in the sense of the applicable accident prevention regulations on electrical installations and equipment. According to these accident prevention regulations, only qualified electricians familiar with this field and experienced in it may take responsibility for supervising or installing the photovoltaic installation. The Vaillant products are ready-to-connect photovoltaic modules that can be installed using suitable plug connectors. „Ready-to-connect equipment“ is understood to mean ready-to-connect, touch-safe plug connections that can only be connected or connected to each other correctly and in the correct sequence.

These ready-to-connect photovoltaic modules with suitable plug connectors can also be wired by non-qualified electricians after they have received instructions from a qualified electrician. Connection work on the inverter, as well as any other electrical work, nevertheless explicitly falls within the remit of a qualified electrician. The installation of the feed-in meter and the connection to the network feed-in point must be carried out by the licenced master electrician exclusively. They alone bear full responsibility for the entire photovoltaic installation and must certify this with their signature.

Photovoltaic installations that are installed parallel to the roof area do not require any planning permission. However, in some federal states, requirements must be complied with for elevated installations. Furthermore, this may lead to restrictions caused by local development plans. Installations that are installed on or attached to listed or protected buildings are strictly subject to approval. The building regulations must always be complied with, e.g. fire protection requirements, structural analysis and stability, traffic safety or clearances to property boundaries.

2.7 Feed-in remuneration and unit registration

The EEG (German Renewable Energy Act) obligates the grid operator to use power from renewable sources in their grid. For every kilowatt hour of power that is generated and the system operator of a renewable energy unit feeds into the grid, they receive feed-in remuneration. The amount of remuneration changes monthly and is announced by the German Federal Network Agency. This means that owners of photovoltaic installations in residential buildings are remunerated. Installations up to 100 kilowatts receive the feed-in remuneration. The local grid operator is the contact person for grid feed-in.

The power that is produced from renewable energies is marketed on the electricity exchange by the grid operators. The price on the exchange is usually lower than the feed-in remuneration that the system operators receive from the grid operators. End users of larger new installations with an output of 100 kWp or more are obligated to sell the power that they create directly on the electricity exchange. As compensation for this, they receive a market premium.

The promotion of the fed-in or generated power in accordance with the German Renewable Energy Act (EEG) and/or the Combined Heat and Power Generation Act (KWKG) requires suitable measurement concepts.

The complex remuneration regulations alone lead to various concepts in practice. The task of selecting the measurement concept lies primarily with the system operator. The grid operator, in turn, is obligated to check the selected measurement concept, in particular to ensure that it complies with the EEG, KWKG and the technical connection conditions.

2.7.1 You must register the installations

As of 1st August 2014, system operators of installations for generating power from renewable energies are obligated to register installations that have been newly started up with the installation register of the German Federal Network Agency. For photovoltaic installations, there has been an obligation to register since 2009. Existing installations only have to be registered if certain events occur that require registration, such as a change to the installed output or if the installation is decommissioned.

You can click on the following link to register your installation:

https://app.bundesnetzagentur.de/pv-meldeportal/

2.7.2 EEG levy for electricity producers

Initially, power self-suppliers have a share in the costs of expanding renewable energies: With the amendment of the EEG, which came into effect on 1st August 2014, private persons and companies who generate electricity using renewable energies, such as photovoltaic or highly efficient combined heat and power systems, and consume this themselves have to pay a reduced proportion of the EEG levy. Installations with an electrical output of up to 10 kilowatts are sometimes excluded from this. The first 10,000 kWh per year are exempt; if you generate electricity beyond that level, you must pay a reduced levy rate. The rate from 2017 is 40 per cent of the regular EEG levy. This reduced EEG levy must be paid to the power grid operator. All systems that were started up before 1st August 2014 are exempt from this levy.

3. Planning the building

A photovoltaic installation can only be operated efficiently if the entire installation is carefully calculated, planned in detail, and installed and started up accordingly.

Note
Yield simulation, shading analysis and inverter design can be carried out using the Solar.Pro.Tool planning software.

3.1 Planning overview

The following overview pages summarise the general planning process.

In addition to the most important steps of the planning process, many important aspects are listed and these must be complied with or checked when planning a photovoltaic system.

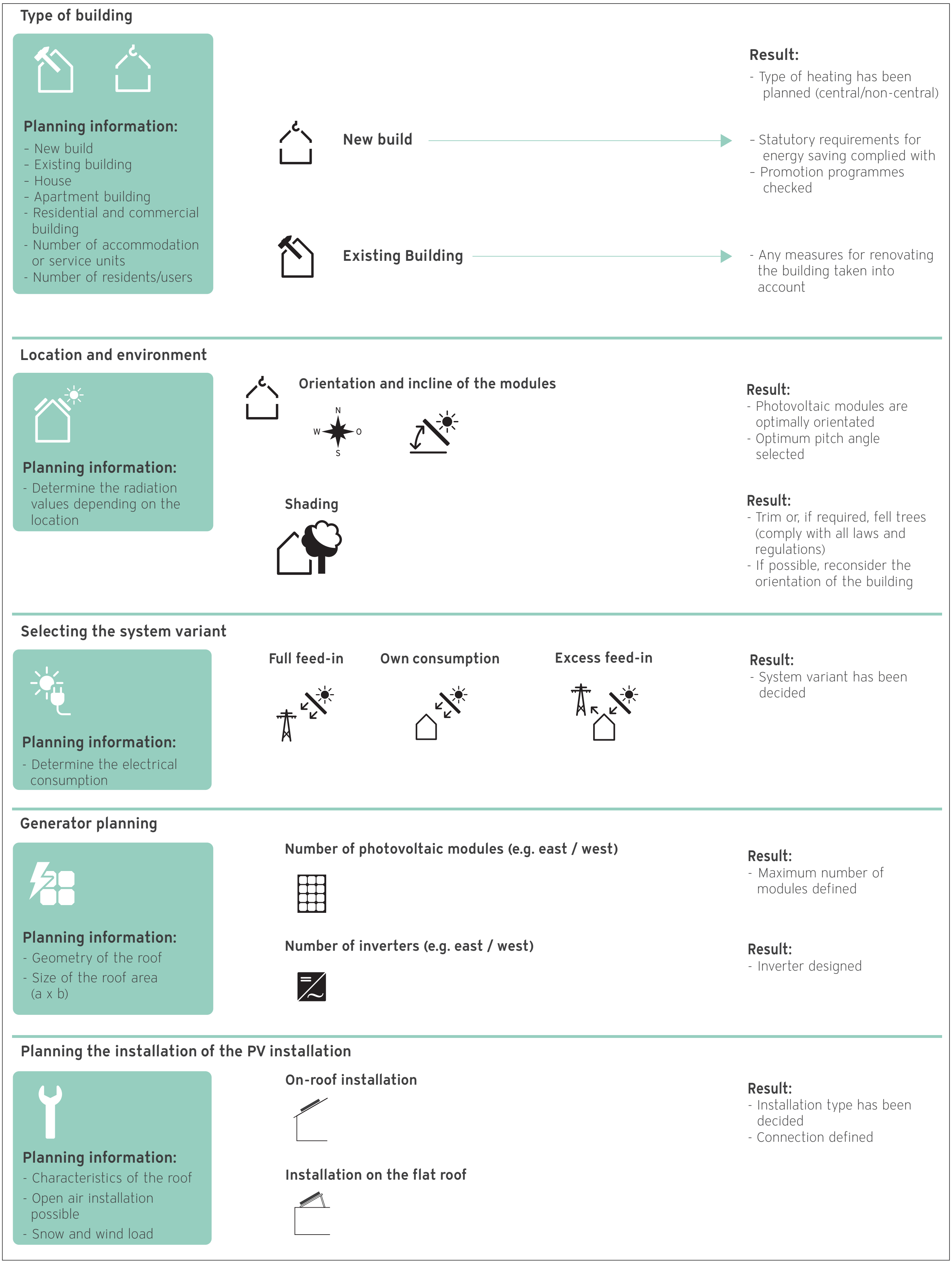


Fig. 31: Planning overview - Part I

3.2 On-site appointment

The following points should be taken into consideration during the on-site inspection and data recording; these are fundamental for good planning:

- Module type, installation concept and installation type based on the customer wishes
- Requested PV output or requested energy yield
- Do you require own consumption? If yes:
- Annual electricity consumption, which consumers (size) are in the home, load curve (estimate)
- The financial framework while taking into consideration the relevant feed conditions
- Usable roof/open space
- Orientation and incline
- Roof shape, roof structure, roof substructure, and type of roofing
- Usable roof ducts (tile vents, free chimney draughts, etc.)
- Shading specifications
- Installation sites for generator connection box, isolation device and inverter
- Meter cabinet and space for other energy meters or optional accessories
- Line lengths, line paths and routing arrangement
- Note the access, especially if tools are required to attach the generator: Crane, scaffolding, etc.
- House site plan for determining the orientation
- Construction plans for the house in order to determine the roof pitch, the usable surface area, and the line lengths
- Photographs of the roof and the meter mounting

3.3 Installing the PV generators

When installing the individual modules, care must be taken to avoid shading. Window dormers, chimneys and trees can result in shading at certain times of the day or year, depending on the position of the sun. The affected modules or cells are then autonomously rendered inoperative by the bypass diode. This means that electrical energy can only be generated on a limited basis.

In principle, the orientation, installation angle and location of the PV generator is subject to the same conditions that apply to solar thermal energy.

The individual components can be designed using suitable software.

A shading analysis is crucial in order to establish the optimal installation site. Corresponding simulation programs as well as special indicators of the sun's orbit are available to assist with this, the latter of which allow the path of the sun to be determined from the perspective of the installation site.

3.4 The bypass diodes – internal protection circuit

In a „normal" operating mode, the same electrical current flows across all the PV cells (electrical series circuit).

If one individual cell is in the shade, e.g. due to foliage, this cell does not generate any electrical energy. Since several cells are connected in a row, this shading significantly reduces the output of the entire module. This cell also converts from the generator to the consumer, whereby part of the electrical energy is converted into heat. These local, very high temperatures can permanently destroy the cell and result in visible black spots known as „hot spots". This permanently reduces the output of the PV module.

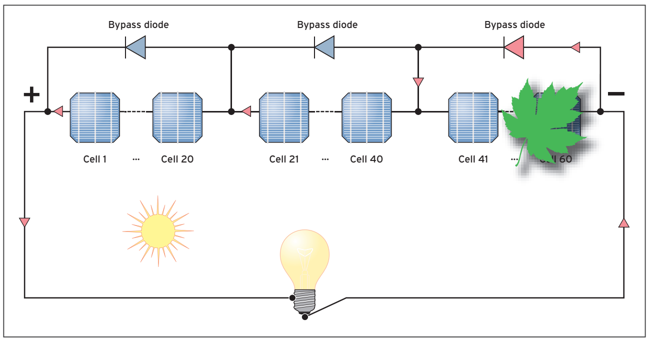


Fig. 32: Internal module wiring with bypass diodes

For this reason, multiple cells in a module are typically protected by bypass diodes. If the voltage becomes too high, the diode opens the bypass and the current no longer flows through the module string that is shaded. The output of the module is temporarily reduced. Once the cell is no longer shaded, the diode closes again and normal generator operation resumes.

3.4.1 Orientation of the modules

The positioning of the bypass diodes and the orientation of the modules can affect power generation to a greater or lesser extent in the event of obscuration, e.g. caused by snow.

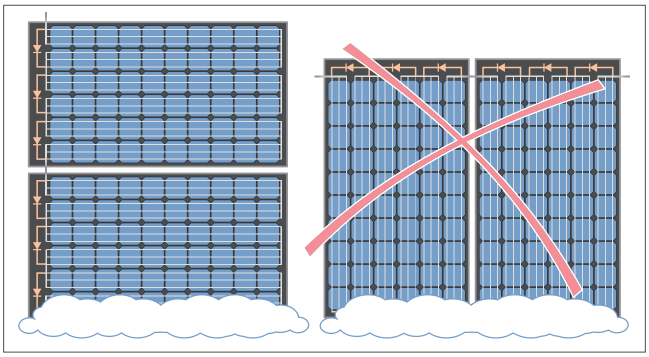


Fig. 33: Orientation of the PV modules

The generator on the left is only slightly limited in its electricity production by the shading of the lower modules. The bypass diode at the bottom protects 20 cells.

On the generator on the right, full generator power is no longer available as at least one cell is affected by the shading in each module string. The bypass diodes have switched off all the cell strings.

3.4.2 Information on flat-roof installation

The clearance between the module rows is also important on elevated PV installations. The modules must not cast shade on each other.

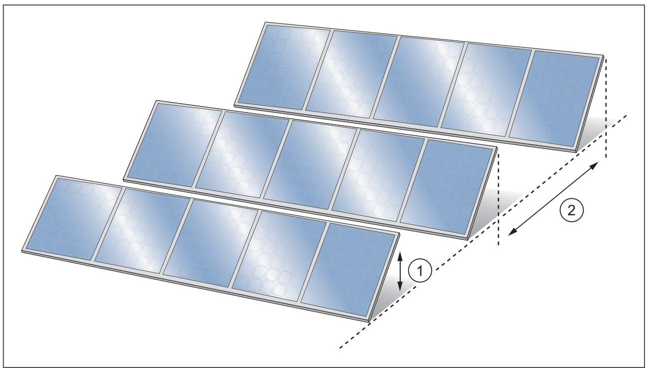


Fig. 34: Clearance for the PV modules

1 Height
2 Clearance = 4 - 6 x height

The following applies as a rule of thumb: The clearance between PV modules should amount to four to six times the height of the mounting frame.

When Vaillant installation accessories are used, the low installation angle means that mutual shading is almost impossible.

Fig. 35: Flat roof system for orientation to the south

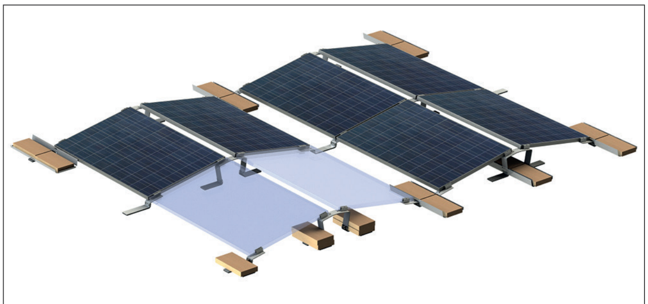


Fig. 36: Flat roof system for east/west orientation

3.5 Dimensioning of the PV generator

The module selection depends on the owner's expectations and the framework conditions for setting up the installation. The module type can be specified by the owner, but can also arise as a result of important questions:

- How high can the investment amount be?
- Is a specific yield planned?
- Which surface is available?
- What is the radiation like at the site?
- Does the owner have building specifications?
- Are there any structural restrictions for an installation?
- Should the electricity be fed into the network or should it be planned as own consumption?

As part of the project planning, the planner should assess which modules can best meet the owner's expectations under the given structural conditions.

Rule of thumb for determining the surface area of a PV installation:

1 kWp = approx. 5-7 m² PV surface area

Rule of thumb for the yield of an installation with south orientation

1 kWp generates 1000 kWh/a

Note
The values may deviate depending on the module type, location and orientation.

3.6 Inverter selection

The inverter works in a voltage window in which it finds the operating point of the maximum generator power in accordance with the existing sunlight (MPP tracking). This voltage window is limited by the minimum MPP voltage and by the maximum permissible voltage of the inverter. When adapting the inverter to the generator, note the following key data:

- The maximum permissible generator power on the inverter,
- The minimum MPP voltage of the inverter,
- The maximum no-load voltage of the inverter and the photovoltaic module

and

- The maximum permissible generator current of the inverter.

The ratio between the nominal generator power and the nominal inverter output should be approx. 0.9 to 1.1 at our degree of latitude. You must avoid exceeding this ratio because the photovoltaic generator then supplies significantly more energy at full load - particularly in summer, but also on sunny winter days - than the inverter can process. If the inverter is permanently overloaded, this may lead to a premature failure. Conversely, however, the nominal generator power can be selected to be lower than the nominal inverter output. In this case, we accept that the inverter has a slightly worse level of efficiency in the partial load range than an inverter with a more coordinated output would have.

PV modules are always connected in series in the **auroPOWER** system.

3.6.1 System combinations and examples

Sample system combinations for single-, double- and triple-row installations are shown below.

The following tables provide an overview of the combination options for the **auroPOWER** modules with the different inverters.

Example 1 – Single-phase inverter

Required: 10 **auroPOWER VPV P 300** PV modules with a total output of 3000 Wp.

This demands the use of an **auroPOWER VPV I 3000/2** 230 V inverter.

All modules can be connected in a row.

Example 2 – Three-phase inverter

Required: 20 **auroPOWER VPV P 305** PV modules with a total output of 6100 Wp.

Six modules are installed in each row.

This demands the use of an **auroPOWER VPV I 6000/1** 400 V inverter.

All modules can be connected together in a row.

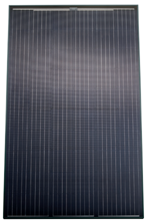
auroPOWER modules and inverter – combination options

System output [kWp]	3,00	3.10	3.05
	auroPOWER photovoltaic module		
	Two rows with five modules VPV P 300/3 M SWF 10 x 0010031114	–	–
	–	Two rows with five modules VPV P 310/3 M BWF 10 x 0010031112	–
	–	–	Two rows with five modules VPV P 305/3 M BBF 10 x 0010031113
	auroPOWER inverter		
	1 x VPV I 3000/2 230 V 0010024750	1 x VPV I 3000/2 230 V 0010024750	1 x VPV I 3000/2 230 V 0010024750

auroPOWER modules and inverter – combination options

System output [kWp]	3,60	3.72	3.66
		auroPOWER photovoltaic module	
	Two rows with six modules VPV P 300/3 M SWF 12 x 0010031114	–	–
	–	Two rows with six modules VPV P 310/3 M BWF 12 x 0010031112	–
	–	–	Two rows with six modules VPV P 305/3 M BBF 12 x 0010031113
		auroPOWER inverter	
	1 x VPV I 4000/2 230 V 0010024751	1 x VPV I 4000/2 230 V 0010024751	1 x VPV I 4000/2 230 V 0010024751

auroPOWER modules and inverter - combination options

System output [kWp]	3,00	3.10	3.05
	auroPOWER photovoltaic module		
	Two rows with five modules VPV P 300/3 M SWF 10 x 0010031114	–	–
	–	Two rows with five modules VPV P 310/3 M BWF 10 x 0010031112	–
	–	–	Two rows with five modules VPV P 305/3 M BBF 10 x 0010031113
	auroPOWER inverter		
	1 x VPV I 3000/1 400 V 0010022892	1 x VPV I 3000/1 400 V 0010022892	1 x VPV I 3000/1 400 V 0010022892

auroPOWER modules and inverter – combination options

System output [kWp]	3,60	3.72	3.66
	auroPOWER photovoltaic module		
	Two rows with six modules VPV P 300/3 M SWF 12 x 0010031114	–	–
	–	Two rows with six modules VPV P 310/3 M BWF 12 x 0010031112	–
	–	–	Two rows with six modules VPV P 305/3 M BBF 12 x 0010031113
	auroPOWER inverter		
	1 x VPV I 4000/1 400 V 0010022893	1 x VPV I 4000/1 400 V 0010022893	1 x VPV I 4000/1 400 V 0010022893

auroPOWER modules and inverter – combination options

System output [kWp]	4,80	4.96	4.88
	auroPOWER photovoltaic module		
	Two rows with eight modules VPV P 300/3 M SWF 16 x 0010031114	–	–
	–	Two rows with eight modules VPV P 310/3 M BWF 16 x 0010031112	–
	–	–	Two rows with eight modules VPV P 305/3 M BBF 16 x 0010031113
	auroPOWER inverter		
	1 x VPV I 5000/1 400 V 00100228954	1 x VPV I 5000/1 400 V 0010022894	1 x VPV I 5000/1 400 V 0010022894

auroPOWER modules and inverter – combination options

System output [kWp]	6,00	6.20	6.10
		auroPOWER photovoltaic module	
	Two rows with ten modules VPV P 300/3 M SWF 20 x 0010031114	–	–
	–	Two rows with ten modules VPV P 310/3 M BWF 20 x 0010031112	–
	–	–	Two rows with ten modules VPV P 305/3 M BBF 20 x 0010031113
		auroPOWER inverter	
	1 x VPV I 6000/1 400 V 00100228955	1 x VPV I 6000/1 400 V 0010022895	1 x VPV I 6000/1 400 V 0010022895

3.7 Module connection

3.7.1 Series connection

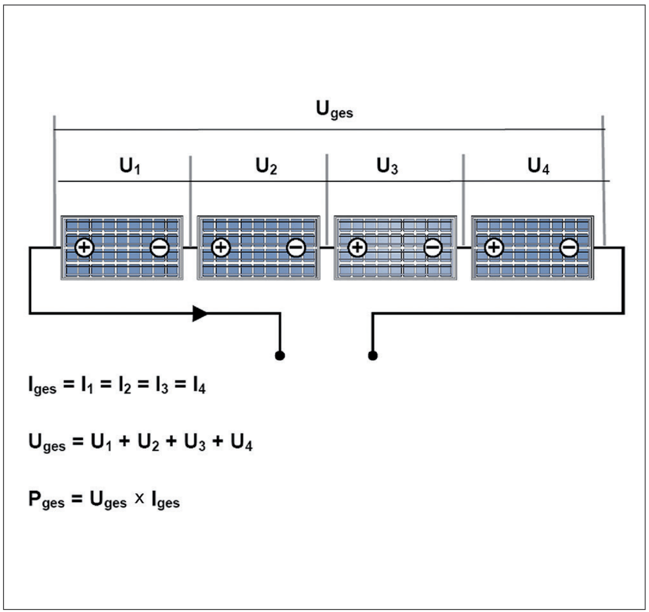


Fig. 37: PV modules – series circuit

When you connect modules in a series circuit, their individual voltages are added up. The current within the series circuit remains the same.

In principle, the MPP currents should remain the same when PV modules are in a series circuit. Different currents reduce the module power.

3.7.2 PV module connection in the auroPOWER system

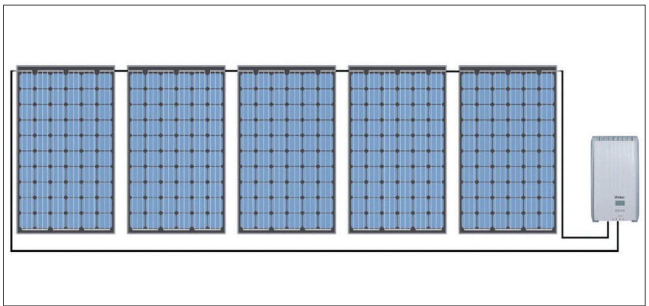


Fig. 38: auroPOWER system – series circuit

PV modules are always connected in line in the **auroPOWER** system.

3.8 Direct current cabling

The generator field is connected to the inverter via a direct current cable. As a rule of thumb for dimensioning direct current cables, the line losses must be lower than 1%. When calculating the cross sections of the line, the maximum possible current in the module string and the line length must be taken into account.

It is essential to ensure that reverse polarity cannot occur.

When securing the electrical wires with cable ties, ensure that the ties are UV-resistant. This is guaranteed by a metallic core incorporated in the cable tie.

The generator field has an all-pole disconnect switch, safeguarded by the DC isolator integrated in the inverter. No separate generator connection box is required.

Various systems that preclude the positive and negative poles being switched are commercially available. The system offered by Vaillant has touch-safe coupling plug technology and allows the plug or coupling to be connected to the direct current cable without the need for tools.

3.8.1 Plug and coupling for DC cable

This system has the advantage that the connections are locking and therefore cannot be rattled loose by wind.

Fig. 39: Plug and coupling for DC cable

It is important for the cables to be either UV-resistant or placed in a safety pipe when outdoors. Vaillant cables are UV-resistant.

3.9 Safety devices

3.9.1 Protection against the effects of lightning

No additional lightning protection system is usually required for photovoltaic installation, because the risk for the building is not increased.

For larger photovoltaic installations of 10 kWp and higher, the Verband der Schadensversicherer (German Association of Insurers) – see VDS directive 2010 – demands lightning and overvoltage protection that must be implemented in accordance with lightning protection class III and the applicable VDE standards.

If a competent person can demonstrate, in accordance with VDE V 0185 Part 2, that the danger from lightning and the risk of damage is low, the insurers will also accept solutions that deviate from the VDS directive.

For a photovoltaic installation that is oriented on the flat roof of a building in an exposed location with a high risk of lightning, suitable lightning protection must be provided.

If a lightning protection system is already in place, the PV installation must be incorporated. During planning and implementation, the VDE directives 0185 Part 1 to 5 must also be observed, with regard to how lightning rods cast shadows, which may lead to yield reductions of up to 20% when arranged unfavourably.

Note
When creating a lightning-protection concept, you must consult specialists.

3.9.2 Surge suppressor

Overvoltages in electrical wires may be created by bad weather and lightning strikes in the immediate surroundings of the building, for example.

The overvoltage protection describes all measures and equipment in the building that deal with the protection of electronic units against the indirect effects of lightning, but also switching operations in the public power grid.

To protect against atmospheric overvoltage, the positive and associated negative pole in the generator should be close together. The smaller the dotted area on the open conductor loop in the generator electrical circuit, the less electricity flows through the module cables.

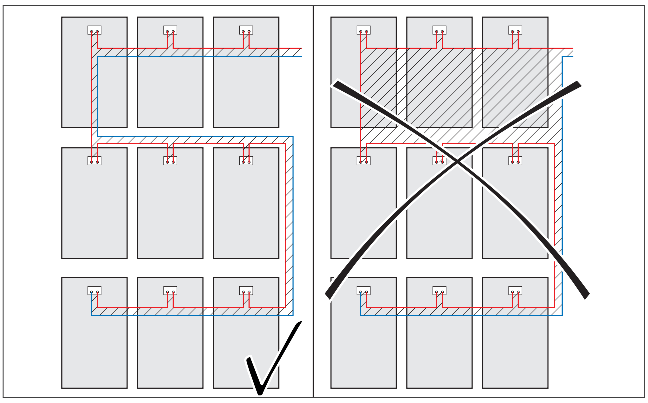


Fig. 40: Overvoltage protection using the correct cable duct in the generator

Usually, overvoltage conductors are installed in the generator connection box, and the equipotential bonding conductor is fed into the generator connection box or the inverters.

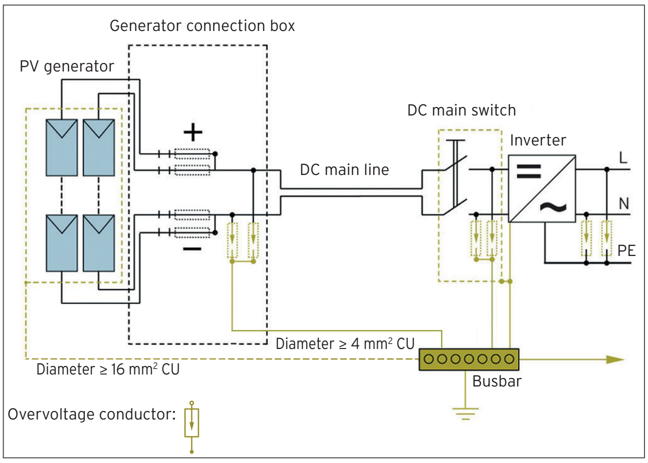


Fig. 41: Wiring diagram for a grid-connected PV installation with overvoltage protection (without including a lightning protection system)

Since all **auroPOWER** inverters are equipped with input-side overvoltage conductors (varistors), you can forego additional overvoltage conductors in the generator connection box when using smaller photovoltaic installations. On the alternating current side, overvoltage protection is always recommended but is not mandatory.

3.9.3 Earthing and potential equalisation

In addition to the lightning protection and overvoltage protection, you must also observe the earthing and potential equalisation in order to ensure that the PV installation operates safely.

In this case, the terms „earthing“ and „potential equalisation“ differ as follows:

Earthing and potential equalisation

	Earthing	Potential equalisation
Definition	The earthing is an electrically conductive connection to the potential of the ground.	The potential equalisation is defined as follows in accordance with DIN VDE 0100, Part 200: "[Potential equalisation is an] electrical connection that ensures that the frames of electrical equipment and external conductive components are at the same, or similar, potential."
Implementation	With (protective) earthing, all exposed metal parts that are not part of the electrical circuit are connected to the earth potential.	First, the main protective conductor, main earthing conductor and main earthing clamp or rail must be connected to each other. Furthermore, conductive components, such as metallic pipelines in the building or substructures of the PV generator are connected to the potential equalisation.
Function	The (protective) earthing should protect people and animals from electric shocks in the event of a fault in the equipment/installations.	The (protective) potential equalisation should prevent differences in potential that may cause a dangerous build-up of sparks, high contact voltages or malfunctions (e.g. in analysers or data transfer).

It is extremely important that the potential equalisation and earthing are installed correctly since an electric shock on roofs can easily cause serious consequential damage (e.g. falling from the roof).

Earthing all metallic parts in an electrical installation is a basic requirement in accordance with DIN VDE 0100, Part 712. Furthermore, the earthing of the module frame in particular, including the substructure for PV installations, must be established using transformerless inverters because a capacitive loading to high DC voltages on the module cannot be ruled out.

3.9.4 Power supply

From the time the inverter is connected and the photovoltaic installation is started up, the electrical installation must always be carried out by the authorised master electrician.

Note
Even if they have not carried out the work themselves, the electrician is liable for the electrical work on the entire installation.

3.10 Power supply and meter equipment

The decisive requirements for connecting photovoltaic installations to the public power grid are contained in the following:

- Standard DIN EN 61727 (IEC 61727),
- Standard VDE 0126-1-1
- The „VDEW directive for the connection to and parallel operation of domestic power generation systems on the low-voltage network“ and
- The technical connection conditions for connecting to the power supply network operator‘s low-voltage network (TAB2000).

After planning and order placement, the photovoltaic installation must be registered with the responsible network operator by a registered master electrician. In doing so, the connection type and network feed-in point is clarified with the network operator.

All **auroPOWER** inverters have protective devices for disconnecting from the power supply, and can therefore be connected in any sub-distributor or to any existing electrical circuits. In the event of problems with the power supply, you should consult an expert in order to find a solution that is acceptable to both sides.

The use of a single-phase ENS is permitted up to an alternating current feed-in power for the photovoltaic installation of 4.6 kVA.

Photovoltaic installations with a three-phase ENS or several single-phase sub-systems with single-phase ENS can be connected up to an output of 30 kVA.

Above 30 kVA, an isolation unit is required in accordance with the VDEW directive.

Alternatively, redundant three-phase voltage monitoring is used in accordance with VDE 0126-1-1.

A grid-connected PV installation consists of the following main components:

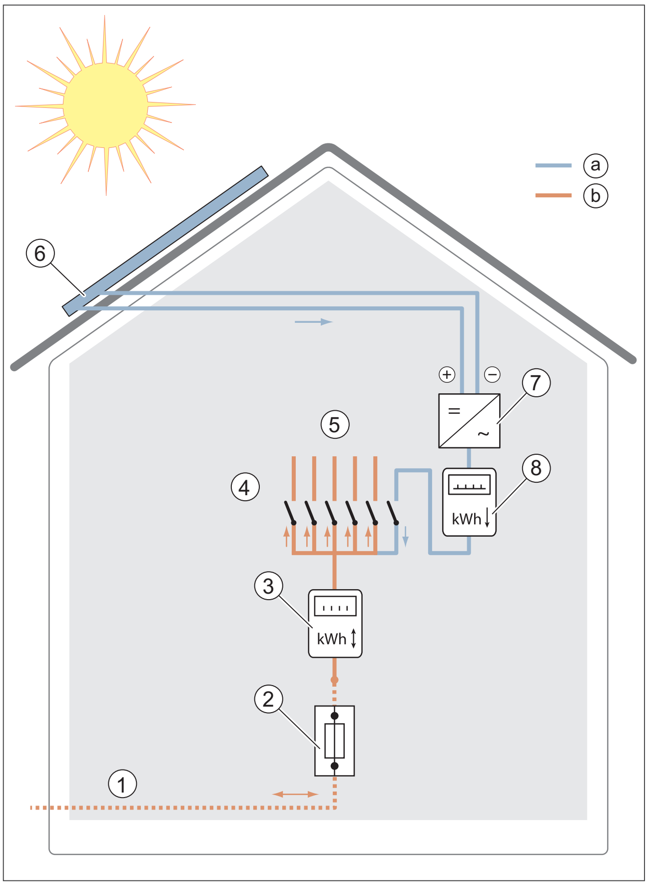


Fig. 42: Main components of a grid-connected photovoltaic installation

1 Energy supply company network 230/400 V
2 Utility connection box
3 Meter for current draw and feed-in
4 Distribution/fuse box
5 Consumer units
6 Photovoltaic generator
7 Grid feed-in appliances/inverters
8 Photovoltaic feed-in meter
a PV current
b PV current and network current mixed

3.10.1 Feed-in meter

Due to the increased feed-in remuneration in accordance with the German Renewable Energy Act (EEG), all of the power that is generated via a feed-in meter is fed into the public power grid at the same time.

Meters that are permitted by the network operator can be hired by the end user. The feed-in meter and all of the measurement, switching and protective devices that are required by the network operator are integrated in the required meter cabinet.

In addition to the reference meter, an existing second meter mounting in the meter cabinet can be used for the feed-in meter. If there is no space for this, an external meter mounting is also set up. In doing so, meters without a non-return device or bidirectional meter are permitted as feed-in meters.

In the past, this again created problems with some network operators. In accordance with the version of the EEG from 2004, network operators must accept the electricity from EEG installations without concluding a contract and must remunerate accordingly. Furthermore, EEG installations take priority over all other electricity generation installations.

Note
A suitable calibrated meter must be permitted by the power supplier.

3.11 Project planning sheet

The following project review sheets can also be filled out and downloaded online in the FachpartnerNET.

Project logging

Photovoltaics (ground installation)

Date

Request based on the information provided by the competent person

Installation location/customer data

Name

Street

Town/City Postcode

Telephone

Installation plan

Project

Manufacturer

Competent person

Name

Customer no.

Street

Town/City Postcode

Telephone/fax

E-mail

Contact partner

Copy to ☐ Sales advisor ☐ VI ☐ Wholesale cust. no.:

Planning steps

Consumption data

Responsible energy supply company (ESCO)

Power consumption [kWh/a]

Power consumption at night [kWh/a] (sunset until sunrise)

Electricity price [ct/kWh]

Anti-cycling times [h]

Geodetic information

Postcode for the construction project

Ground elevation above sea level [m]

Exposed location (e.g. isolated building on a hill) ☐ Yes ☐ No

Page 1

Fig. 43: Project review sheet for the ground installation, page 1

Terrain category

☐ Terrain category I ☐ Terrain category II ☐ Terrain category III ☐ Terrain category IV

☐ Mixed profile I (inland, mixed profile between terrain category II and III)

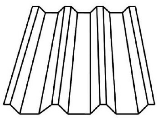
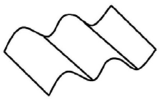
☐ Mixed profile II (coastal areas with a width of 5 km inland from the coast and on the Baltic Islands)

☐ Mixed profile III (North Sea Islands)

Roof construction/grid integration

Roofing and roof properties

Without specifying the load-bearing capacity of the roof, it is not possible to plan safely and to a high quality. We therefore request that you check the residual load-bearing capacity (e.g. by looking at design plans/consulting with a statistician) before sending in the project request form.

☐ Bituminous sheeting ☐ Sheeting ☐ Gravel filling

☐ On-roof insulation

☐ Trapezoidal sheet metal ☐ Corrugated roof ☐ Other

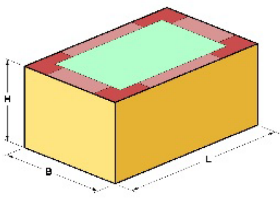
Building type

☐ Residential building ☐ Non-residential building

Potential shadows caused by

☐ Roof structures ☐ Neighbouring trees/building

Note: Create a diagram (in the appendix).



L (south/north side) [m]

W (east/west side) [m]

H (building height) [m]

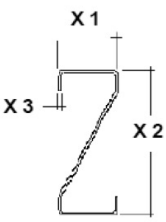
Attic height [m]

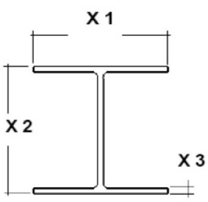
Coefficient of friction for the structural protection mat

Roof construction

☐ Full formwork Material ☐ Reinforced concrete ceiling

☐ Rafter; girder (vertical) ☐ Roof beams (horizontal)

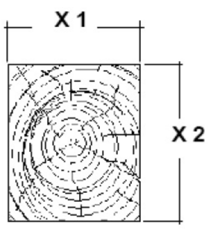




X1 [cm]

X2 [cm]

X3 [cm]



X1 [cm]

X2 [cm]

Clearance between rafters [cm]

Clearance to first rafter verge [cm]

Formwork thickness [cm]

Clearance between roof beams and the edge of the roof [cm]

Clearance to first roof beam eave/ridge [cm]

Residual load-bearing capacity [kg/m²]

Page 2

Fig. 44: Project review sheet for the ground installation, page 2

Information about routing cables Removing the module field -> inverter [m] ☐

Removing the inverter -> utility connection [m] ☐

Cables ☐ No cables

Module selection

☐ Mono 300 Wp – best price/performance ratio
Silver frame, white film

☐ Mono 305 Wp – highest optical standards
Black frame, black film

☐ Mono 310 Wp – max. output
Black frame, white film

Recording private consumption

☐ Private consumption recording for dynamic
Feed-in management (70% at the feed-in point)

☐ Actuation of el. consumers (e.g. PV Ready function Wp)

Forecast (only if required)

☐ Yield forecast

Installation/delivery date Expected or required ☐

Other information/comments and diagram of the roof area with dimensions

Page 3

Fig. 45: Project review sheet for the ground installation, page 3

Project review sheet for the pitched-roof installation (3-pages)

Project logging

Photovoltaics (pitched roof)

Date

Request based on the information provided by the competent person

Installation location/customer data

Name

Street

Town/City Postcode

Telephone

Installation plan

Project

Creator:

Competent person

Name

Customer no.

Street

Town/City Postcode

Telephone/fax

E-mail

Contact partner

Copy to ☐ Sales advisor ☐ VI ☐ Wholesale cust. no.:

Planning steps

Consumption data

Responsible energy supply company (ESCO)

Power consumption [kWh/a]

Power consumption at night [kWh/a] (sunset until sunrise)

Electricity price [ct/kWh]

Anti-cycling times [h]

Geodetic information

Postcode for the construction project

Ground elevation above sea level [m]

Exposed location (e.g. isolated building on a hill): ☐ Yes ☐ No

Page 1

Fig. 46: Project review sheet for the pitched-roof installation, page 1

Terrain category

☐ Terrain category I ☐ Terrain category II ☐ Terrain category III ☐ Terrain category IV

☐ Mixed profile I (inland, mixed profile between terrain category II and III)

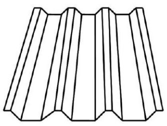
☐ Mixed profile II (coastal areas with a width of 5 km inland from the coast and on the Baltic Islands)

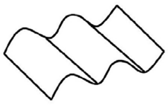
☐ Mixed profile III (North Sea Islands)

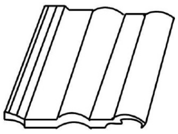
Roof construction/grid integration

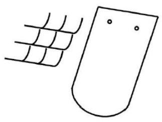
Roofing and roof properties

Without specifying the load-bearing capacity of the roof, it is not possible to plan safely and to a high quality. We therefore request that you check the residual load-bearing capacity (e.g. by looking at design plans/consulting with a statistician) before sending in the project request form.







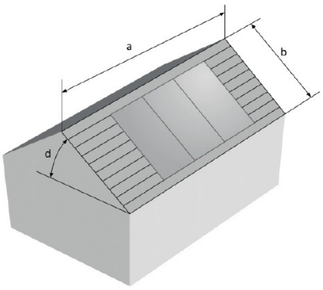


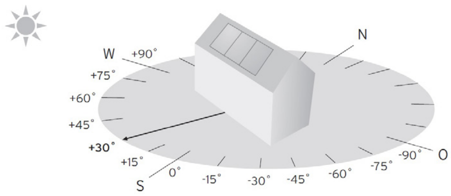
☐ Trapezoidal sheet metal ☐ Corrugated roof ☐ Frankfurt-style tile ☐ Slate/beaver-tail tile

☐ On-roof insulation ☐ Other [ ]

Building type

☐ Residential building ☐ Non-residential building





Length a (ridge) [m] [ ]

Length b (verge) [m] [ ]

Roof pitch d [°] [ ]

Ridge height above ground level [ ]

Alignment S [°] [ ]
(Deviation from the orientation to the south)

Potential shadows caused by ☐ Dormer/hearth

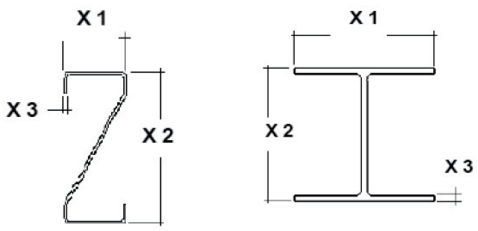
☐ Neighbouring trees/building

Page 2

Fig. 47: Project review sheet for the pitched-roof installation, page 2

Roof construction

☐ Rafter; girder (vertical)

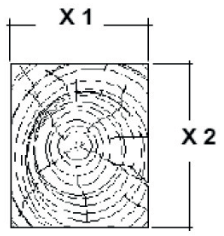


X1 [cm] ☐

X2 [cm] ☐

X3 [cm] ☐

☐ Roof beams (horizontal)



X1 [cm] ☐

X2 [cm] ☐

Clearance between rafters [cm] ☐

Clearance to first rafter verge [cm] ☐

Roof lathing thickness [cm] ☐

Clearance between roof beams and the edge of the roof [cm] ☐

Clearance to first roof beam eave/ridge [cm] ☐

Information about routing cables Removing the module field -> inverter [m] ☐

Removing the inverter -> utility connection [m] ☐

Cables ☐ No cables

Module selection

☐ Mono 300 Wp – best price/performance ratio
Silver frame, white film

☐ Mono 305 Wp – highest optical standards
Black frame, black film

☐ Mono 310 Wp – max. output
Black frame, white film

Recording private consumption

☐ Private consumption recording for dynamic
Feed-in management (70% at the feed-in point)

☐ Actuation of el. consumers (e.g. PV Ready function Wp)

Forecast (only if required)

☐ Yield forecast

Installation/delivery date Expected or required ☐

Other information/comments and diagram of the roof area with dimensions

Page 3

Fig. 48: Project review sheet for the pitched-roof installation, page 3

4. Installing the modules

The assembly of the modules is a not negligible step in the planning. Depending on the roof substructure, roofing and meteorological conditions, the type and number of assembly components differ.

4.1 Overview of the installation types

In principle, all parts of the building surface that are exposed to direct sunlight are suitable for installing photovoltaic installations: Pitched and flat roofs, as well as façades.

We distinguish between ancillary and integrative solutions. Futhermore, unused open spaces can, of course, also be used.

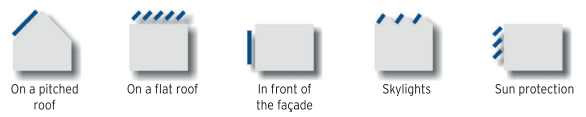


Fig. 49: Installation types for the PV generator

Due to the installation type, the structural design and other general parameters, there are individual answers to the question of which installation system can be used.

Furthermore, special requirements and directives apply for façade and overhead installation.

4.2 Installation instructions

Installing a PV installation may make it necessary for different tradesmen (electricians, roofers, HVAC tradesmen, façade designers, etc.) to work together. The guarantee obligation for earlier trade work that involved incursions into the roof skin must be observed; any required roof ducts for flat roofs should always be designed by a roofer.

The plug connections that are safe to touch and protected against polarity reversal also allow the proficient „non-electrician" to carry out the electrical installation on the direct current side.

The electrician who is approved by the power supply network operator must carry out the network-side connection of the inverter and starts up the photovoltaic installation.

Note
Even if they have not carried out the direct-current-side work themselves, the electrician is liable for the electrical installation of the entire installation.

4.2.1 Observing the safety regulations for roofing work

For installation on pitched roofs, you must observe the safety regulations for working on a roof.

As of a height of three metres, suitable fall protection must be provided in accordance with the occupational safety and accident prevention regulations for the professional associations. Protective barriers, safety net, rope protection or safety scaffold can be used. The type of fall protection must be tailored to the local conditions.

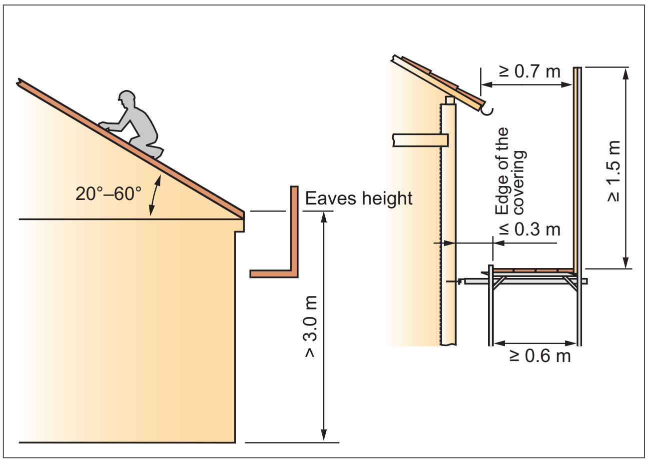


Fig. 50: Safety scaffold for roofing work

4.2.2 Installing the generator

The careful and correct installation of the rafter anchors, the fastening rails, the modules and the PV cable is the basic prerequisite for long-term operating safety and the leak tightness of the roof skin.

When installing the generator field, you must pay attention to the special features of the direct current installation. If light hits the modules, these are also live during set-up, the electrical installation and any required maintenance work. In the event of insulation faults in direct current cables, an uninterrupted electric arc may form, meaning that an installation that is safe from earth faults and short circuits is required.

When designing the protective technology, you must note that conventional alternating current fuses and switches cannot be used, because the short-circuit current from PV generators is only approx. 20% above the nominal current. Lightning protection (if required), earthing and overvoltage protection for the generator must be taken into consideration.

4.2.3 Information about routing the lines

The roof duct for the PV cables is provided by suitable ventilation pipes. In order to prevent mechanical damage, the wiring for the generator field should not lie on the roof skin but, instead, it should be secured to the mounting frame using temperature-, weather- and UV-resistant cable ties. You must avoid large-scale line loops.

Within the building, the string lines are fed along the shortest route to the generator connection box. All direct current cables in the building should be labelled as such.

4.3 Installing the inverter

The inverter must be installed in a location that is as consistently cool and dry as possible – without direct sunlight (observe the permissible environmental temperature).

Furthermore, you must comply with the minimum clearances to other units, cupboards, ceilings and similar; the free flow of air around the housing and the heat sink must not be hindered.

When installing the unit in a control cabinet, forced ventilation must be provided in order to ensure sufficient heat removal for the inverter.

Installation at eye level makes it easier to ready the display.

4.4 On-roof installation

While flat roofs allow the planner of a PV system certain freedoms, pitched roofs mostly require a specific orientation and incline for the modules. The suitability of the roof must therefore be checked before the planning phase. This includes, in particular, a location-based yield assessment while taking into consideration the specified orientation and incline.

For on-roof installation, the modules are mounted above the existing roofing with a metal substructure. The roofing remains in place and retains its draining function.

When retrofitting on existing roofs, on-roof installation is usually the most cost-effective variant because the installation and material costs are low.

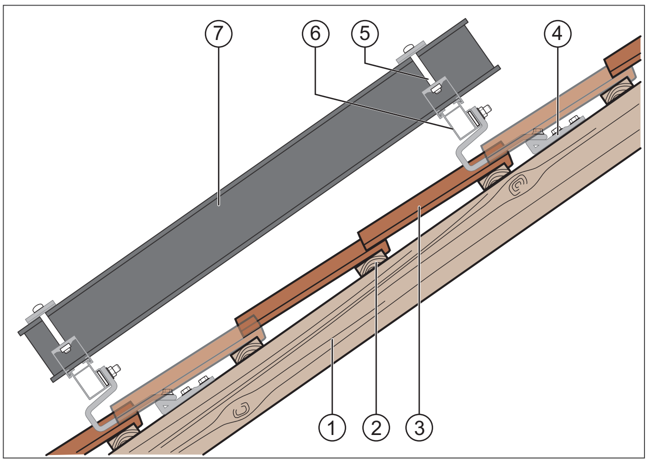


Fig. 51: On-roof installation – schematic diagram

1 Rafter
2 Roof batten
3 Roof tile
4 Roof hook
5 Clamping element
6 System carrier (aluminium rail)
7 PV module

In the roof area, fixing points must be created for mounting the mounting frame. The method of securing that is used depends on the existing roofing. The structure can be anchored to the roof construction or can be secured directly onto the roofing.

The substructure must be able to absorb the forces that are generated at the generator and transfer these to the roof structure.

Apart from the thermal stresses in high summer, the modules are mainly exposed to mechanical loads.

4.4.1 Horizontal or vertical arrangement of the PV modules

In accordance with the intended module arrangement on the mounting frame, different substructures must be planned:

- Single-layer substructure for a vertical module arrangement
- Two-layer substructure (cross rail system) for a horizontal module arrangement

The **single-layer substructure** for the vertical installation of the PV modules comprises the following main components.

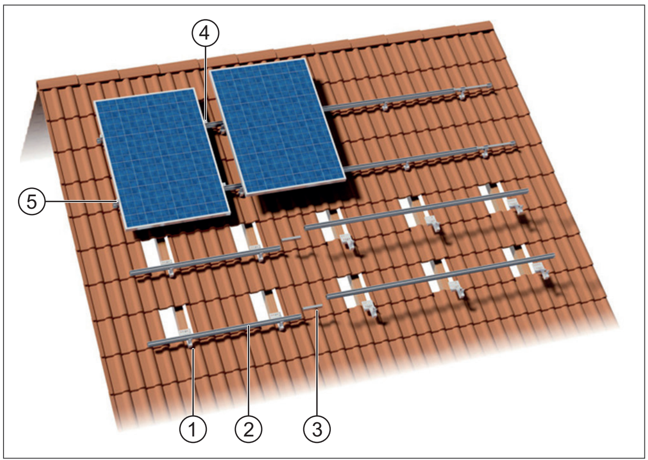


Fig. 52: Single-layer substructure

1 Roof hook
2 System carrier (aluminium rail)
3 Rail connector
4 Middle clamp
5 End clamp

In order to install the PV modules horizontally on the mounting frame, additional vertical rails for a two-layer substructure (cross rail system) must be planned.

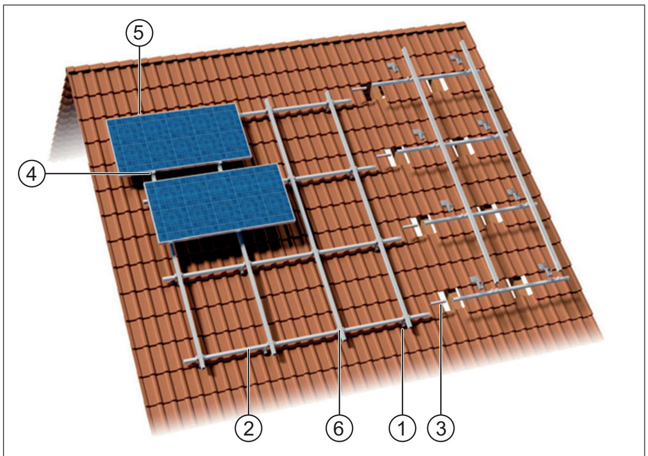


Fig. 53: Two-layer substructure (cross rail system)

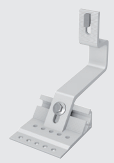
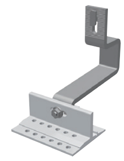
1 Roof hook
2 System carrier (aluminium rail)
3 Rail connector
4 Middle clamp
5 End clamp
6 Cross rail connector

4.4.2 Roof anchors

Roof anchors are routed through the roof tiling and fixed to the rafters or the roof batten as part of the installation.

There are different roof anchor sets for on-roof installation on nearly every type of roof with tiles and slates.

Roof anchor types

Element	Description
	Roof hook, standard For common roof tiles Article number 0020228531
	Roof hook, heavy load For common roof tiles Article number 0010029479
	Roof hook for plain tile roofing Article number 0020228534
	Roof hook for slate roofing Article number 0020228536

The ability to adjust the height in the roof batten and rail area means that a level PV field is possible even on uneven roof areas, and it can therefore be easily installed on old and new buildings.

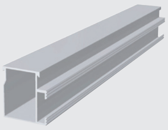
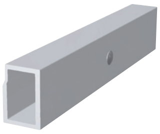
The roof duct for the electric cable is created through the roofing felt membrane and a ventilation tile/pipe duct tile.

4.4.3 Rail set for on-roof installation

Aluminium rails are installed on the roof anchor and, together with the module, these rails are quick and straightforward to fix to the roof anchor using a retainer.

The roof anchor, rail and retainer all come with a single profile that allows the modules to be orientated with ease while remaining stable and easy to install.

Rail set

Element	Description
	Aluminium rail, 40 x 37 mm & 60 x 37 mm, Length 2080 mm for installing the PV module Article number 0020228532 (40 x 37 mm, silver) Article number 0020228542 (40 x 37 mm, black) Article number 0010029474 (60 x 37 mm, silver)
	Rail connector for aluminium rail 40 x 37 mm and 60 x 37 mm, Article number 0020273246 (40 x 37 mm) Article number 0010029476 (60 x 37 mm)

When installing multiple modules alongside one another, the rails are connected by simple plug-in rail connectors.

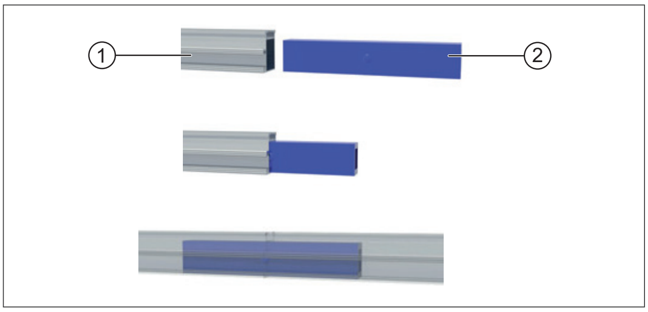


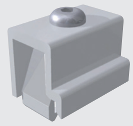
Fig. 54: Sequence of the aluminium rails using rail connectors

1 Aluminium rail
2 Rail connector for aluminium rail

4.4.4 Cross rail connector

Crossing points can be implemented using cross rail connectors. Depending on the static requirements of the site and the installation situation, one or two cross rail connectors must be assigned for each crossing point.

Cross rail connector

Element	Description
	Cross rail connectors for aluminium rails Article number 0020228545

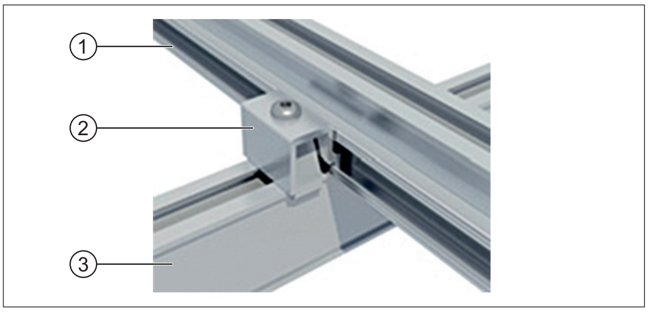


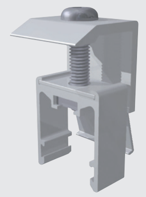
Fig. 55: Cross rail connector at crossing points

1 Aluminium rail
2 Cross rail connector
3 Aluminium rail (horizontal)

4.4.5 Retainers for on-roof installation

The retainers (clamping elements) for fixing modules and mounting rails to the roof anchor are available in two versions:

Retainer types for on-roof installation

Element	Description
	End clamp for securing the module on an aluminium rail Article number 0020276017 (silver) Article number 0020276026 (black)
	Middle clamp for securing the module on an aluminium rail Article number 0020276021 (silver) Article number 0020276030 (black)

The single-sided retainers (end clamps) are used to install modules in series, above and below.

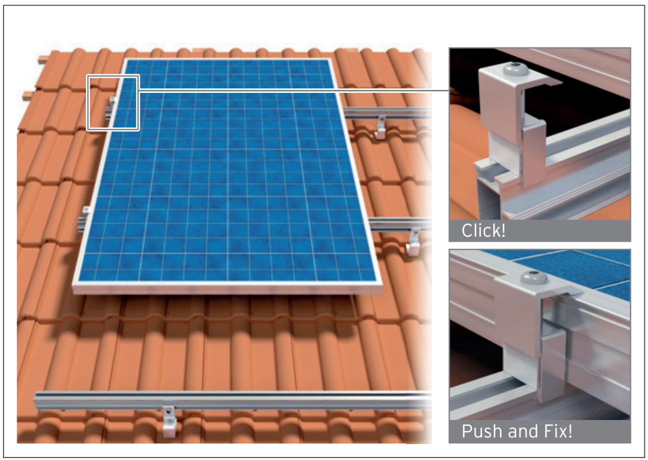


Fig. 56: Installing end clamps

When installing modules next to each other, the double-sided retainers (end clamps) can be used to secure two modules.

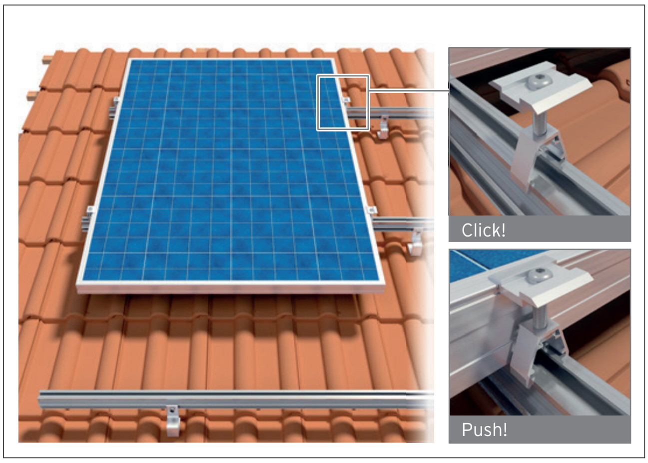


Fig. 57: Attaching middle clamps

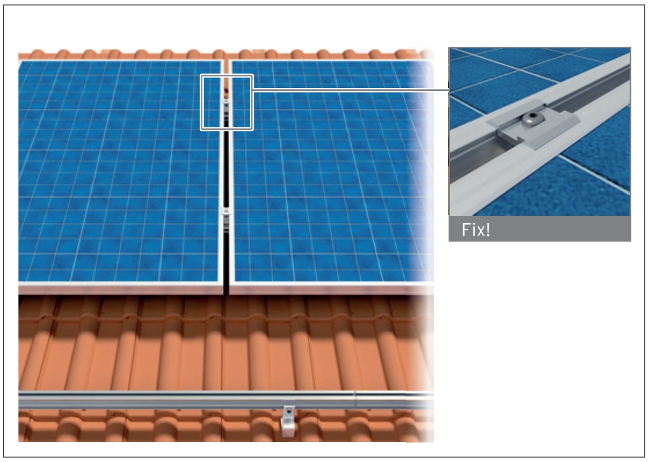


Fig. 58: Using middle clamps to secure modules

However, the structural design requirements (snow load, roof pitch and height of the installation site) must be checked in the process.

In doing so, observe the application limits and clamping ranges with regard to the frame thickness (42 mm or 35 mm) and loads from the following table.

4.4.6 Installation drawings for load levels I to V

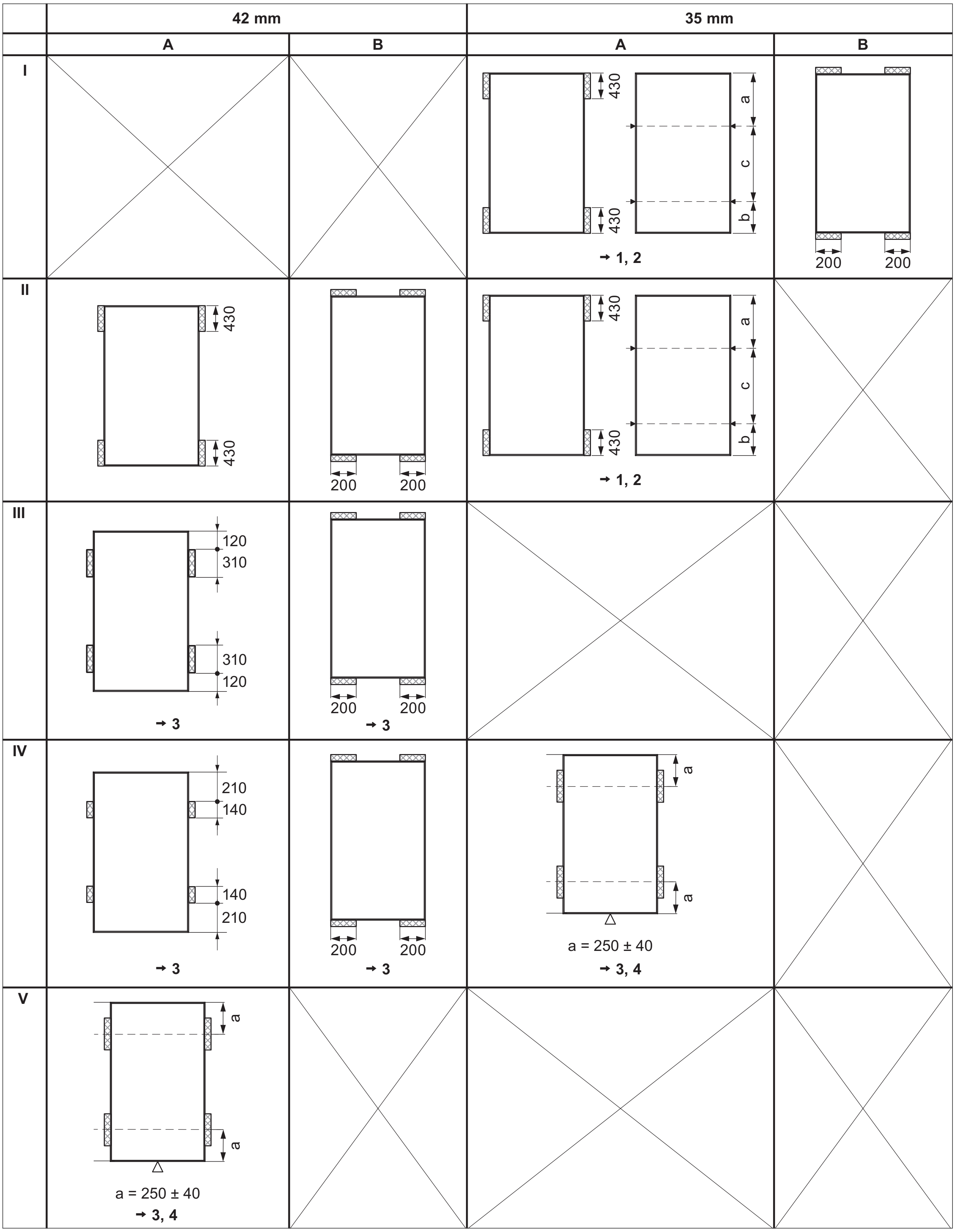


Fig. 59: Installation drawings for load levels I to V

Key for the table showing the installation drawings for load levels I to V

Marking	Meaning
42 mm	Product with 42 mm frame
35 mm	Product with 35 mm frame
A	Clamp system (long side of the PV module, horizontal/vertical)
B	Clamp system (short side of the PV module, horizontal/vertical)
I	Load level I: Pressure and suction up to 1400 Pa (approx. 140 kg/m²)
II	Load level II: Pressure and suction up to 2400 Pa (approx. 240 kg/m²)
III	Load level III: Pressure up to 3900 Pa (approx. 390 kg/m²), suction up to 2400 Pa (approx. 240 kg/m²)
IV	Load level IV: Pressure up to 5400 Pa (approx. 540 kg/m²), suction up to 2400 Pa (approx. 240 kg/m²)
V	Load level V: Pressure up to 7500 Pa (approx. 750 kg/m²), suction up to 2400 Pa (approx. 240 kg/m²)
1	Option 1 (symmetrical clamping), option 2 (asymmetrical clamping)
2	Where 430 ≤ a ≤ 560, select b ≥ 300 and c ≥ 800. a and b can be inverted.
3	Caution: Maximum permissible suction load of 2400 Pa
4	At least one support
	Permissible clamping range
Δ	Support

4.4.7 Component list for common tiled roofs

To make ordering simple and straightforward, Vaillant offers compatible sets that must be ordered in the right quantity depending on requirements and the installation configuration.

The sets already contain the required parts – from roof hooks and the appropriate number of end or middle clamps, through to the fastening clip (see also the section on photovoltaic system accessories).

Component list for common tiled roofs

Set	Number of modules per row for a single-row installation									
	1	2	3	4	5	6	7	8	9	10
Basic set, pitched roof Article number 0020275993 (silver) or 0020275999 (black)	1	1	1	1	1	1	1	1	1	1
Expansion set + 1 pitched roof Article number 0020275997 (silver) or 0020276004 (black)	–	1	–	1	–	1	–	1	–	1
Expansion set + 2 pitched roof Article number 0020275998 (silver) or 0020276003 (black)	–	–	1	1	2	2	3	3	4	4
2080 mm Aluminium rail	1	2	3	4	5	6	7	8	9	10

Accordingly, during the **two- or three-row installation,double or triple the number** of sets and aluminium rails are required.

Note
Each project must be checked using the Solar. Pro.Tool. Depending on the wind and snow load, the number of required roof hooks may be higher than the number of roof hooks that is available in the sets.

4.4.8 Installation clearances

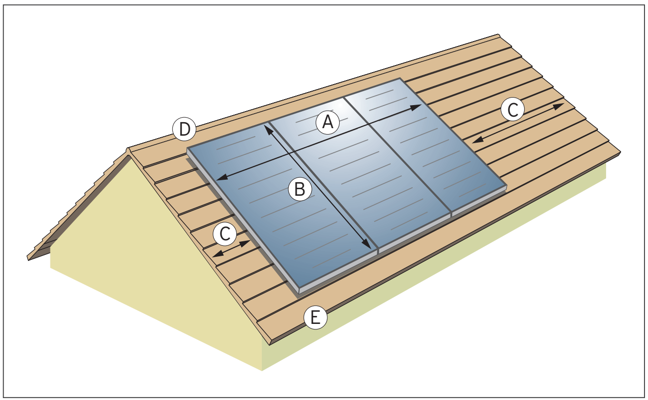


Fig. 60: Clearances and dimensions for on-roof installation

A Width of the module field
B Height of the module field
C Minimum clearance to the edge of the roof (verge): Whichever is the smaller value: 1/10 of the building's width (gable width) or 1/5 of the building's height from the side edges
D Clearance from the roof ridge: At least two rows of tiles or whichever is the smaller value: 1/10 of the building's length (eaves length) or 1/5 of the building's height from the eaves to the ridge
E Minimum clearance from the bottom edge of the roof (like D)

4.5 Snow load zones

The characteristic values for snow loads (Sk) are determined for regional zones (snow load zones) which have different intensities.

A distinction is made between five different snow load zones: Zone 1, 1a, 2, 2a and 3. The intensity of the snow loads increases from zone 1 to zone 3.

In the North German Plain, snow loads of up to multiple times the calculated values are measured in rare cases. The relevant authority can fix the calculated values in the regions in question and these values must then also be assessed as extraordinary effects according to DIN EN 1991-1-3/NA: 2010-12.

Certain locations in snow load zone 3 may also see values higher than those derived from the equation. You can get information on the snow load in these locations from the relevant local authorities. This concerns, for example, areas such as the Harz Mountains or high-altitude regions in the Fichtel Mountains, Reit im Winkl, Obernach am Walchensee, etc.

(Source: http://schneelast.info/node/1)

The snow load zones can be found in the following table.

Snow load zones

Town/city	Snow load zone	Height in metres above mean sea level
Aachen	2	173
Augsburg	1a	494
Bergisch Gladbach	1	129
Berlin	2	34
Bielefeld	2	120
Bochum	1	93
Bonn	1	60
Bottrop	1	49
Brunswick	2	74
Bremen	2	3
Bremerhaven	2	0
Chemnitz	3	309
Cottbus	2	71
Darmstadt	1	144
Dortmund	1	93
Dresden	2	113
Duisburg	1	32
Düsseldorf	1	36
Erfurt	2	195
Erlangen	2	326
Essen	1	77
Frankfurt	1	117
Freiburg	2	273
Fürth	2	293
Gelsenkirchen	1	43
Gera	2	204
Hagen/Hamm (Westphalia)	2 (1)	156
Halle	2	89
Hamburg	2	6
Hanover	2	55
Heidelberg	1	114
Heilbronn	2	188
Herne	1	61
Hildesheim	2	88
Ingolstadt	1a	372
Jena	2	179
Kaiserslautern	2	253
Karlsruhe	1	119
Kassel	2	164
Kiel	2	5
Koblenz	1	72
Cologne	1	53
Krefeld	1	39
Leipzig	2	112
Leverkusen	1	52
Lübeck	2	9
Ludwigshafen	1	97
Magdeburg	2	50
Mainz	1	110
Mannheim	1	101
Moers	1	30
Mönchengladbach	1	55
Mülheim	1	263
Munich	1a	518
Münster	1	55
Neuss	1	43
Nuremberg	1	309
Oberhausen	1	48
Offenbach (Main)	1	106
Oldenburg	2	8
Osnabrück	2	97
Paderborn	2	159
Pforzheim	2	290
Potsdam	2	70
Recklinghausen	1	76
Regensburg	1a	359
Remscheid	2	312
Reutlingen	2	379
Rostock	3	13
Saarbrücken	1a	190
Salzgitter	2	107
Schwerin	2	38
Siegen	2a	290
Solingen	1	188
Stuttgart	2	245
Ulm	1	478
Witten	1	135
Wolfsburg	2	63
Wuppertal	1	244
Würzburg	1	177
Zwickau	2	267

4.5.1 Calculating the snow loads (Sk)

The following formula is used to determine the value for snow loads (S_k) based on the snow load zone. If the calculated value is smaller than the minimum value, this calculated value must be adopted.

You can find information on snow load zones, for example, at: www.schneelast.info.

Calculating the snow loads

Snow load zone	Calculation formula	Minimum snow load value in kN/m²
Zone 1	S_k = 0.19 + 0.91 x ((A+140)/760)²	> 0.65 (kN/m²)
Zone 1a	S_k = 1.25 x [0.19 + 0.91 x ((A+140)/760)²]	> 0.81 (kN/m²)
Zone 2	S_k = 0.25 + 1.91 x ((A+140)/760)²	> 0.85 (kN/m²)
Zone 2a	S_k = 1.25 x [0.25 + 1.91 x ((A+140)/760)²]	> 1.06 (kN/m²)
Zone 3	S_k = 0.31 + 2.91 x ((A+140)/760)²	> 1.10 (kN/m²)

*A = Ground level in metres above sea level

4.5.2 Number of roof anchors required depending on the snow load zone, the roof pitch and the height of the installation site

In principle, at least four roof anchors are required per module for on-roof installation. This applies to all locations in Germany up to 400 m above sea level, independent of the roof pitch and the snow load zone.

The static load presented by snow is the deciding factor. Accordingly, the roof pitch, local altitude, snow load zone, rafter clearance and, in particular, the wind load zone play a particularly important role.

At installation sites higher than 400 m above sea level, the number of roof anchors required is to be determined as follows:

Number of roof anchors required depending on the snow load zone, the roof pitch and the height of the installation site

Height of the installation site above sea level [m] up to	Snow load zone														
	1			1a			2			2a			3		
	Roof pitch from:														
	30°	45°	60°	30°	45°	60°	30°	45°	60°	30°	45°	60°	30°	45°	60°
400	•	•	•	•	•	•	+2 Da	•	•	–	•	•	–	+2 Da	•
600	+2 Da	•	•	+2 Da	•	•	–	+2 Da	•	–	–	•	–	–	•
900	–	+2 Da	•	–	–	•	–	–	•	–	–	•	–	–	•
1200	–	–	•	–	–	•	–	–	•	–	–	•	–	–	•

• = permitted, – = not permitted, +2 Da = two additional roof anchors required

Note
For wind load zones above 2 and rafter clearances of > 80 cm, a statistics for the individual case must be created.

Sample calculation:

Roof pitch: 45°

Height of the installation site: 900 m above sea level

Snow load zone: 1

Number of modules (n): 4

Result from the table: 2 x n = 2 x 4 = 8
Eight roof anchors must also be installed.
Two per module.

4.6 Ground installation, flat-roof installation

Fig. 61: Flat-roof system for orientation to the south

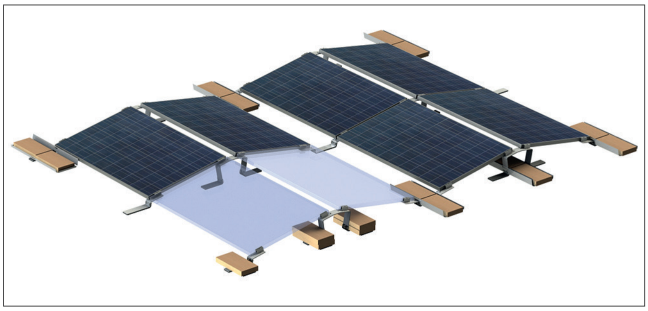


Fig. 62: Flat-roof system for east/west orientation

Ground installation makes it possible to install the modules on flat roofs or on any level surface.

Flat roofs are roofs with no roof pitch or only a slight roof pitch.

Below you can find a list of the features of ground installation:

- Orientation with respect to the sun and incline angle can be set optimally.
- The required weight loads are taken into consideration depending on the building's height and the modules' ground clearance.
- The load-bearing capacity of the roof is taken into consideration, in particular if it is weighted with load plates and additional snow load.
- If several rows of modules are connected one behind the other, a sufficient distance must be selected to prevent potential shadows.

The flat-roof installation supporting the modules comprises the following main components:

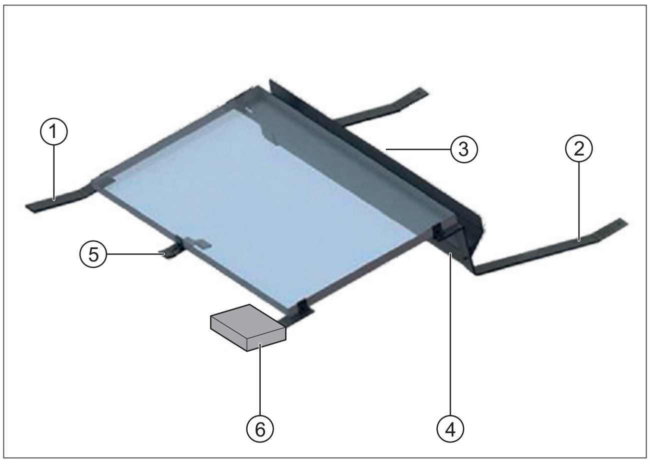


Fig. 63: Set-up example for flat-roof support, orientation to the south

1 Start part
2 Connector
3 Wind deflector
4 Alpin snow load panel
5 Alpin snow load support
6 Ballast stone

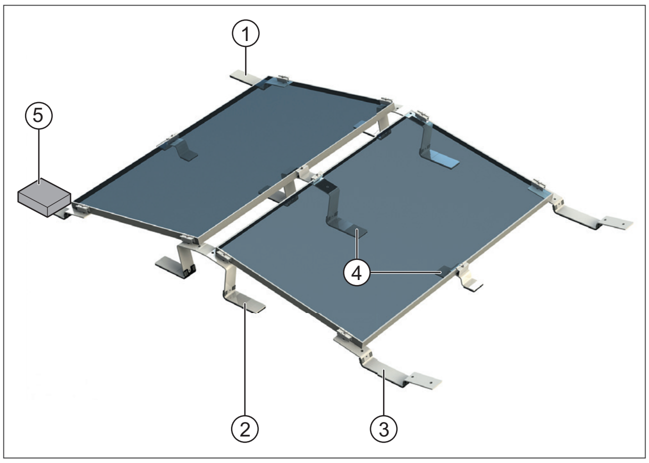


Fig. 64: Set-up example for flat-roof support, east/west orientation

1 Start part/end part
2 Centre section
3 Connector
4 Alpin support foot (optional)
5 Ballast stone

Frame systems are available for flat-roof installation or ground installation and these systems permit an incline of 10° for orientation to the south and 10° for east/west orientation.

This installation system allows for a flat-roof installation without roof penetration.

The modules must be installed on the flat roof in such a way that they are able to withstand the maximum wind and snow loads at the place of installation. The following regulations according to DIN EN 1991-1-4 must be observed in this regard.

The standard system is designed for wind and snow loads up to maximum 2.4 kN/m², while the Alpin system is designed for maximum 4.4 kN/m². The values for the loads are a combination of tare weight, wind pressure and snow. You should therefore check beforehand in which snow- and wind-load zone you want to use the system. The system's wind channel has been checked and the system is UL-certified.

The load-bearing capacity of the roof (structural design of the roof) must also be tested in this case in particular to verify whether it can withstand the weighting required for module installation.

Ground installation/flat-roof installation enables the floating installation with load plates and loading weights on the roof, as well as other options. When load plates are used, these have to be additionally weighted on-site (e.g. 40 x 40 cm paving slabs).

This kind of installation does not involve drilling into or damaging buildings' roof skin or subsoil. You must note the roof's structural design and the weighting required according to the wind load zones in this case.

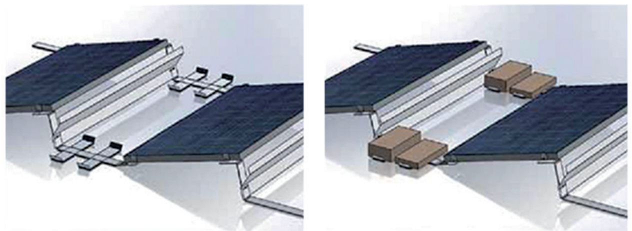


Fig. 65: Load plates for orientation to the south

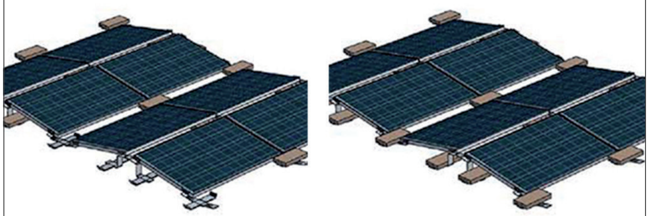


Fig. 66: Load plates for east/west orientation

To ensure a stable base, we recommend using suitable structural protection mats that have high coefficients of friction and also protect the roof seal against damage. These may also minimise the loads to an even greater extent in some circumstances.

The appropriate weights must be applied to each rack depending on the location and the building's height.

Note
The design of the module field size and the required loads must be calculated using the Solar.Pro.Tool.

4.6.1 Wind load zone

Fig. 67: Wind load zones

The wind load zones result in basic wind speeds which play a decisive role in weight distribution. The basic wind speeds can be found in the table.

Wind load zones and basic wind speeds

Wind load zone	Basic wind speed	Wind strength
1	Up to 72 km/h	Approx. 9
1	Up to 81 km/h	Approx. 10
2	Up to 90 km/h	Approx. 10
3	Up to 99 km/h	Approx. 11
4	Up to 108 km/h	Approx. 12

Edge areas on flat roofs

Wind causes maximum lift points and pressure peaks in the corner and edge areas. When installing the collectors, make sure that you comply with minimum clearances of at least 1 m from the edge of the roof in these areas (DIN 1055 part 4).

Wind load zone 1-4

In accordance with the design loads which form the basis of DIN 1055-4 and -5, the following minimum edge clearances for the collectors must be complied with:

1. Whichever is the smaller value: 1/10 of the building's length (eaves length) or 1/5 of the building's height from the eaves to the ridge.
2. Whichever is the smaller value: 1/10 of the building's width (gable width) or 1/5 of the building's height from the side edges.

4.6.2 Component list for ground installation/flat roofs

To make ordering simple and straightforward, Vaillant offers compatible sets that must be ordered in the right quantity depending on requirements and the installation configuration.

The sets already contain the required parts – from supports, structural protection mats, and the appropriate number of end or middle clamps, through to the fastening clip (see also the section on photovoltaic system accessories).

Note
In addition to the sets, loads are required depending on the wind and snow load. These must be calculated individually.

Component list for flat roof system, south (elevated)

Sets Flat roof system, south 10° (elevated)	Number of modules per row (continuous without gaps)									
	1	2	3	4	5	6	7	8	9	10
Basic set for first row Article number 0020276006	1	1	1	1	1	1	1	1	1	1
Basic set for each additional row Article number 0020273239	1	1	1	1	1	1	1	1	1	1
Expansion set for first row Article number 0020228559	–	1	2	3	4	5	6	7	8	9
Expansion set as of the second row Article number 0020228560	–	1	2	3	4	5	6	7	8	9
Alpin expansion set (optional) for installing 1 x PV module Article number 0020273240										
Ballast trough expansion set (optional) for installing 1 x PV module Article number 0020228530										

Example

For an **orientation to the south** with **nine modules** in three rows, 1 x basic set 0020276006, 2 x expansion set 0020228559, 2 x basic set 0020273239 and 4 x expansion set 0020228560 are required:

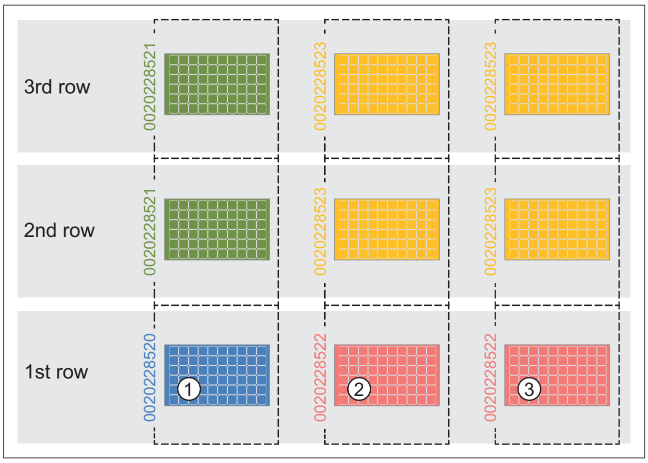


Fig. 68: Flat roof system, south – ordering diagram

Flat roof system, south – ordering diagram

1st row	1st module 2nd + 3rd module	1 x 0020276006 2 x 0020228559
2nd row	1st module 2nd + 3rd module	1 x 0020273239 2 x 0020228560
3rd row	1st module 2nd + 3rd module	1 x 0020273239 2 x 0020228560
Optional	9 x 0020273240 9 x 0020228530	

Component list for flat roof system, east/west 10° (elevated)

Sets Flat roof system, east/west 10° (elevated)	Number of modules per row (continuous without gaps)				
	2	4	6	8	10
Basic set for first row Article number 0020276010	1	1	1	1	1
Basic set for each additional row Article number 0020273245	1	1	1	1	1
Expansion set for first row Article number 0020273242	–	1	2	3	4
Expansion set as of the second row Article number 0020273243	–	1	2	3	4
Alpin expansion set (optional) for installing 1 x PV module Article number 0020273244					
Ballast trough expansion set (optional) for installing 1 x PV module Article number 0020228530					

Example

For an **east/west orientation** with **18 modules** in three rows, 1 x basic set 0020276010, 2 x expansion set 0020273242, 2 x basic set 0020273245 and 4 x expansion set 0020273243 are required:

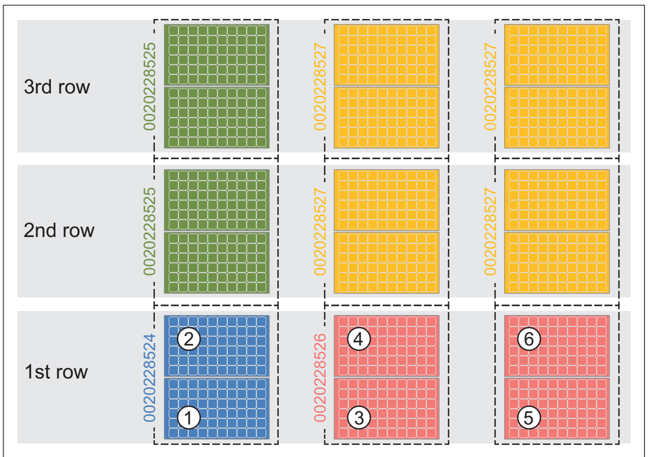


Fig. 69: Flat roof system, east/west 10° - ordering diagram

Flat roof system, east/west 10° - ordering diagram

1st row	1st + 2nd module 3rd-6th module	1 x 0020276010 2 x 0020273242
2nd row	1st + 2nd module 3rd-6th module	1 x 0020273245 2 x 0020273243
3rd row	1. +2. Module 3rd-6th module	1 x 0020273245 2 x 0020273243
Optional	9 x 0020273244 18 x 0020228530	

4.7 Potential equalisation

For the safety reasons that are explained in section 3.9, a potential equalisation or earthing of the PV installation must be provided and is directly connected to the main earth rail/ main potential equalisation rail of the building.

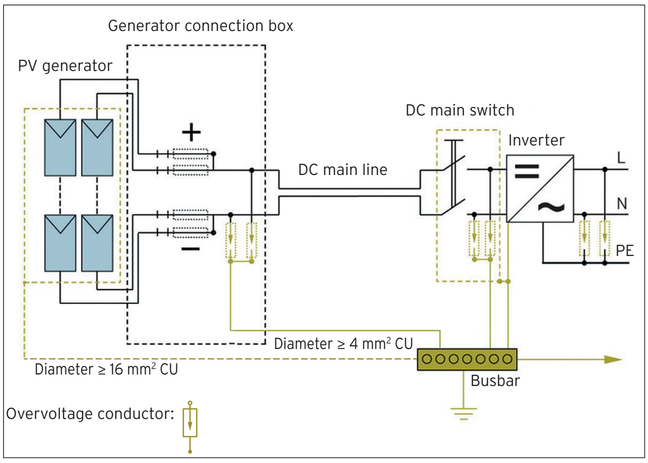


Fig. 70: Wiring diagram for a grid-connected PV installation with overvoltage protection (without including a lightning protection system)

The earthing and protective bonding conductors must be labelled with green-yellow in accordance with DIN VDE 0100, Part 510, but another colour of label is also permitted.

In accordance with DIN VDE 100, Part 410, the cross sections of the lines for the protective bonding conductors should not be smaller than 6 mm² copper and 16 mm² aluminium. However, as a cross-section for the potential equalisation and earthing, 16 mm² copper or 25 mm² aluminium lines are recommended and should be complied with for additional functions (e.g. earthing or lightning protection).

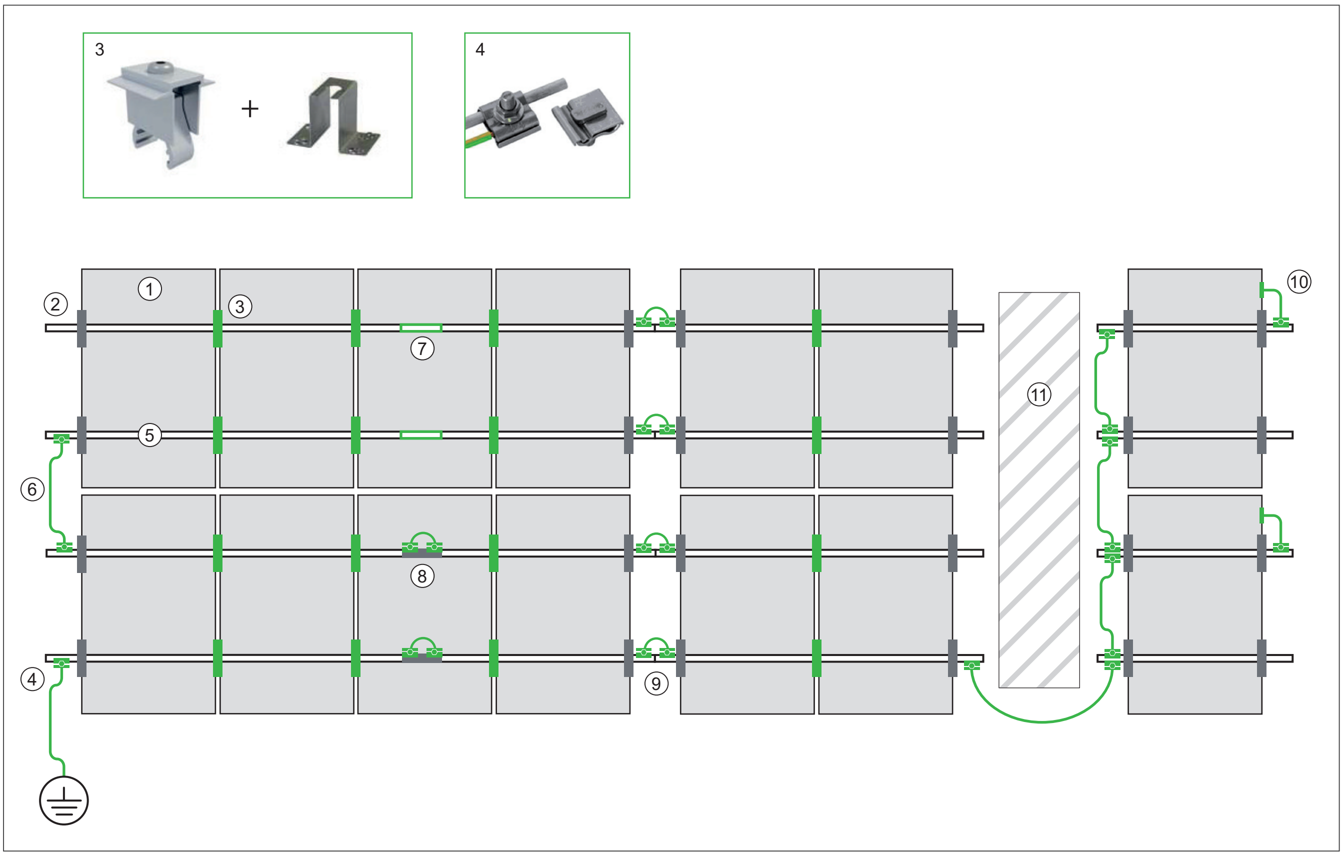


Fig. 71: Earthing of the roof substructure, part I

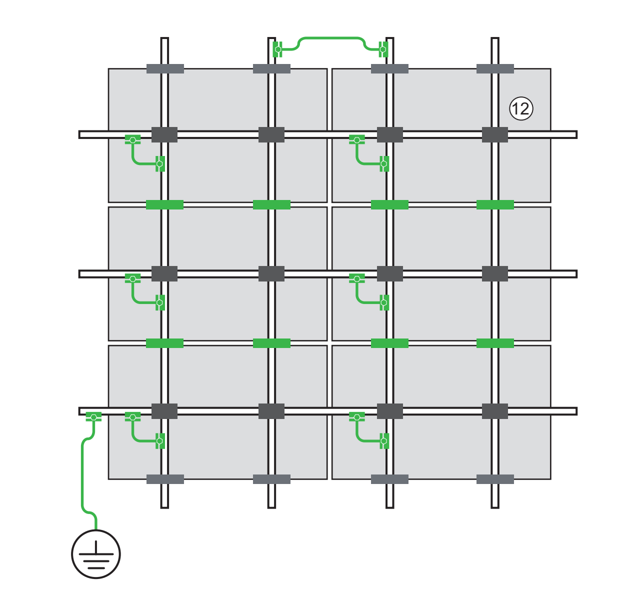


Fig. 72: Earthing of the roof substructure, part 2

1 Photovoltaic module
2 End clamp
3 Middle clamp with earthing plate
4 Universal earthing terminal
5 Mounting rail
6 Connection of two module rails
7 Rail connector with potential equalisation
8 Rail connector without potential equalisation
9 Expansion gap
10 Potential equalisation with earthing point on the module
11 Interfering surface
12 Cross connector

In a general way, the potential equalisation is implemented for the PV modules by establishing an electrically conductive connection from the modules, via the rails, to the busbar.

An electrically conductive connection from the modules to the substructure can, in general, be established via two different routes.

If multiple modules are installed in a row, the connection can be established via the middle clamps (3). However, for an electrically conductive connection, an earthing plate (which must be ordered separately) must be inserted into the middle clamp.

The second option for establishing an electrically conductive connection is possible using an earthing point (10) on the module and a universal earthing terminal (4). When establishing the earthing point, you must ensure that the module frame from Vaillant is made of anodised aluminium. The anodised coating on the module frame protects against environmental influences but is also electrically insulating. For this reason, the surface on which the earthing point is established must be damaged.

Once an electrically conductive connection has been guaranteed between the modules and the substructure, the substructures must be electrically conductively connected to each other. On the one hand, the connection must be set up between individual module rail rows (6). This connection is implemented by using two universal earthing terminals (4). On the other hand, you must pay attention to the connection of two module rails in the same row. If the rail connector has a potential equalisation (7), an electrically conductive connection must be provided between two rails. If, however, a rail connector without potential equalisation is used, an electrically conductive connection must also be established here between the rails (8) using universal earthing terminals (4).

The procedure is similar for expansion joints: If an expansion joint is required, an electrically conductive connection must always be established (9) using two universal earthing terminals (4). In addition, for crossing rails, a connection (12) with two universal earthing terminals (4) must be established because an electrically conductive connection is not provided by the cross rail connector.

If all of the components are electrically connected to each other, the connection from the generator field to the busbar must be established.

5. Monitoring and control

The installation monitoring of a photovoltaic installation offers an overview of your yield data and therefore provides additional operating safety. End users can call up this data online in order to evaluate it statistically or present it graphically. Furthermore, the online access allows for remote monitoring system of the installation, an automatic if a fault occurs and easier energy balancing.

5.1 Installation monitoring and visualisation

The operating data for the photovoltaic installation is recorded by the inverter. This can be viewed directly on the inverter via a graphical display or using the integrated online portal function remotely. Thanks to this monitoring, the yields can be tracked and faults can be detected in good time.

5.2 Feed-in management and energy monitoring

In combination with the three-phase electricity meter, which is connected directly to the inverter via a Modbus (RTU) interface, consumption within the building can be measured and dynamic feed-in management can take place.

The feed-in management wiring centre provides the option to implement feed-in management using a photovoltaic installation.

This allows a ripple control receiver, for example, to be connected for the respective distribution network operator.

The digital signals that the ripple control receiver supplies can, as an alternative, be supplied by the Vaillant **eloPACK** battery bank system.

In addition, an electrical consumer can be switched on or off via a potential-free switching contact. This switching contact is used for the „PV Ready" function on the heat pump if an **eloPACK** battery bank is not incorporated in the system.

Fig. 73: Three-phase electricity meter for dynamic feed-in management

Fig. 74: Feed-in management wiring centre

5.3 SG Ready

The SG Ready label (SG = Smart Grid) is given to heat pump series that feature control technology that enables the individual heat pump to be incorporated into an intelligent power grid. Heat pump manufacturers and operating companies can apply for this label.

The label is awarded in Germany only and is not valid elsewhere.

The following Vaillant heat pumps come with the SG Ready label:

- flexoTHERM exclusive
- flexoCOMPACT exclusive
- aroTHERM
- aroTHERM split
- aroSTOR

5.3.1 Installation-relevant units and accessories

- Vaillant **flexoTHERM** VWF 57/4, VWF 87/4, VWF 117/4, VWF 157/4, VWF 197/4 heat pump
- Vaillant **flexoCOMPACT** VWF 58/4, VWF 88/4, VWF 118/4 heat pump
- Vaillant **aroTHERM** VWL 55/3, VWL 85/3, VWL 115/2, VWL 155/2 heat pump and the additional VWZ MEH 61 decoupler module
- Vaillant **aroTHERM split** VWL 35/5 AS, VWL 55/5 AS, VWL 75/5 AS, VWL 105/5 AS and VWL 125/5 AS heat pump

also

- Vaillant **VRC 700** system control
- Vaillant VR 70/ VR 71 system expansion module
- Two external relays each with one N/C contact and one N/O contact with gold contacts for 24 V/20 mA
- System connection no. 0020212759 for **flexoTHERM**
- System connection no. 0020212760 for **aroTHERM**
- System connection no. 0020234171 for the **aroTHERM split**

OR

- Vaillant **aroSTOR** VWL B 290/4 and VWL BM 290/4 domestic hot water heat pump

5.3.2 Functionality

The smart grid switching statuses - 0:0, 0:1, 1:0, 1:1 - are passed to the Vaillant system by an on-site transfer point. This must consist of two relays.

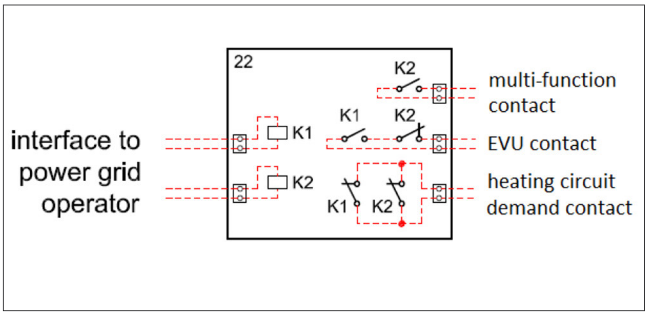


Fig. 75: On-site signal transfer point/processing by the energy supply company

Key for signal processing for the flexoTHERM and flexoCOMPACT

flexoTHERM/flexoCOMPACT	Terminal
Multi-function contact	FB/OT "neutral ground" from the HMU terminal block X 41
Energy supply company contact	S 21 from the HMU
Heating circuit demand contact	S 2 of VR 70 module

Key for signal processing for the aroTHERM

aroTHERM	Terminal
Multi-function contact	ME VWZ AI or MEH 61
Energy supply company contact	VWZ AI or MEH 61
Heating circuit demand contact	S 2 of VR 70 module

Switching status 1 or 1:0 (K1 = 1; K2 = 0) - Forced switch-off

Operation: The heat pump and the electric back-up heater are off.

Switching status 2 or 0:0 (K1 = 0; K2 = 0) - Normal operation

Operation: No restriction on heat pump operation.

Switching status 3 or 0:1 (K1 = 0; K2 = 1) - Switch-on recommendation

Operation: The system stores energy in the domestic hot water cylinder by triggering cylinder boost until the target temperature that is set in the **VRC 700** is reached. The system then stores energy in the buffer cylinder (if available) by increasing the temperature to the target value set in the **VRC 700** control.

In the case of domestic hot water generation, the forced charging prevails over the time programmes for hot water. Cylinder charging is carried out outside of the set time periods.

If there is no heat requirement and switching status 3 is present, no cylinder charging takes place in heating mode.

Switching status 4 or 1:1 (K1 = 1; K2 = 1) – Forced switch-on

Operation: The system stores energy in the domestic hot water cylinder by triggering cylinder charging. The system then stores energy in the buffer cylinder by increasing the temperature to the target value set in the **VRC 700** and a variably adjustable offset. The temperature value is above the value set for switching status 3.

For domestic hot water, see switching status 3.

Heating mode deviation: Due to an additional virtual heating circuit (with variably adjustable separate target value (from x-y)), an artificial heat requirement is generated in any case, which leads to the buffer cylinder being charged to the target value and the variably adjustable offset (0–20 K). (Offset status 3 = Offset status 4).

A normal heating circuit is not affected by the cylinder charging.

Note
When using several real heating circuits, a usable heating circuit is no longer necessary if you want to use status 4. A non-mixed or mixed heating circuit can be used for this.

5.3.3 Connecting to the flexoTHERM/ flexoCOMPACT exclusive

1. Connecting the transfer point to the Vaillant system as can be seen from the system wiring 0020212759
2. The series circuit of the N/O contact of K1 and the N/C contact of K2 must be connected to the **S21** ESC contact of the flexoTHERM/flexoCOMPACT heat pump. The N/O contact of K2 must be connected to the **FB** „multi-function input“ and **OT** „neutral ground“ of terminal block X41.
3. The parallel switching of the N/C contact of K1 and the N/C contact of K2 must be connected to the **S2** contact of the external VR 70 module. The VR 70 module is installed next to the heat pump and is integrated into the eBUS system.

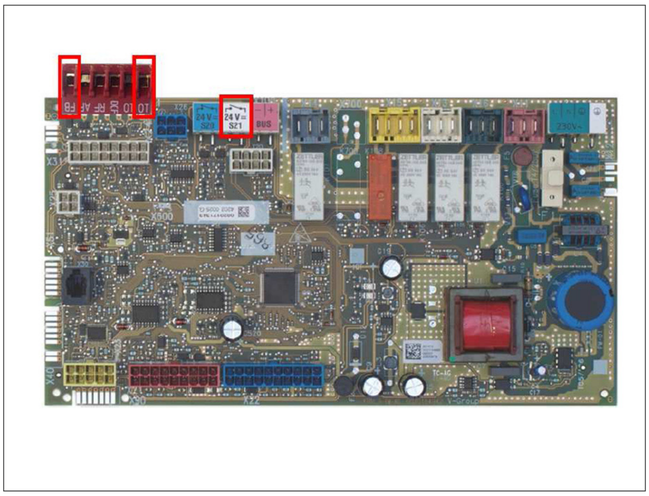


Fig. 76: Control PCB with highlighted energy supply company (ESC) input (S21) and multi-function input (FB and neutral/earth)

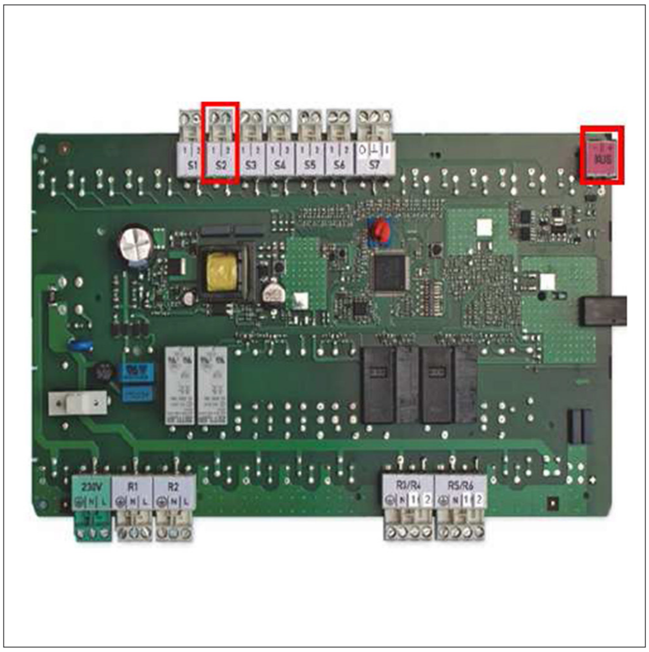


Fig. 77: VR 70 PCB with highlighted S2 input and eBUS connection

5.3.4 Connecting to aroTHERM

1. Connecting the transfer point to the Vaillant system as can be seen from the system wiring 0020212760
2. Connect the N/O contact of K1 and the N/C contact of K2 to the ESC input so that they are connected in series.
3. Connect the N/O contact of K2 to the ME input.
4. The parallel switching of the N/C contact of K1 and the N/C contact of K2 must be connected to the **S2** contact of the external VR 70 module. The VR 70 module is installed next to the heat pump and is integrated into the eBUS system.

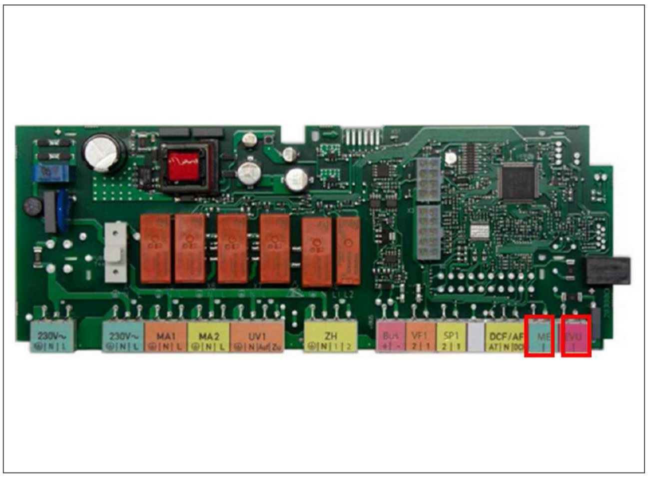


Fig. 78: Decoupler module PCB with selected multi-functional input and ESC input

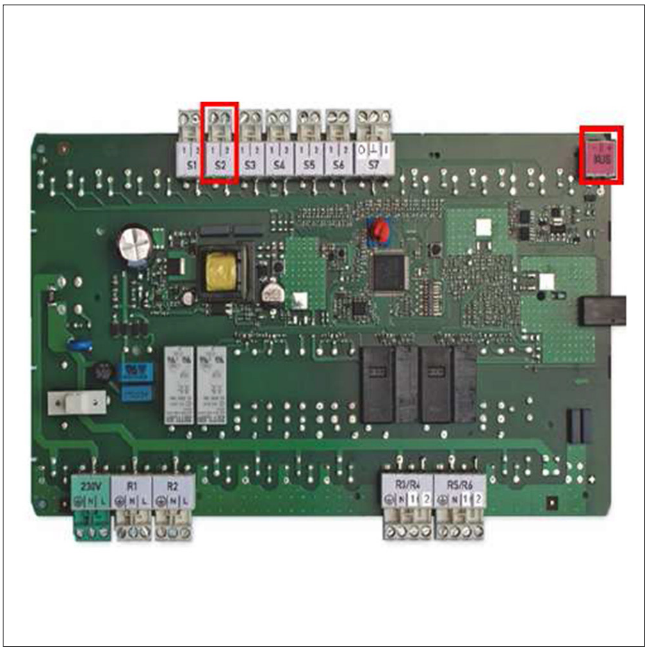


Fig. 79: VR 70 PCB with highlighted S2 input and eBUS connection

5.3.5 Connecting to the aroTHERM split

1. Connecting the transfer point to the Vaillant system as can be seen from the system wiring 0020234171
2. The series-wired N/O contact from K1 and N/C contact from K2 must be connected to the **S21** ESC contact of the aroTHERM split heat pump. The N/O contact of K2 must be connected to the **FB** „multi-function input“ and **OT** „neutral ground“ of terminal block X41.
3. The parallel switching of the N/C contact of K1 and the N/C contact of K2 must be connected to the **S2** contact of the external VR 70 module. The VR 70 module is installed next to the heat pump and is integrated into the eBUS system.

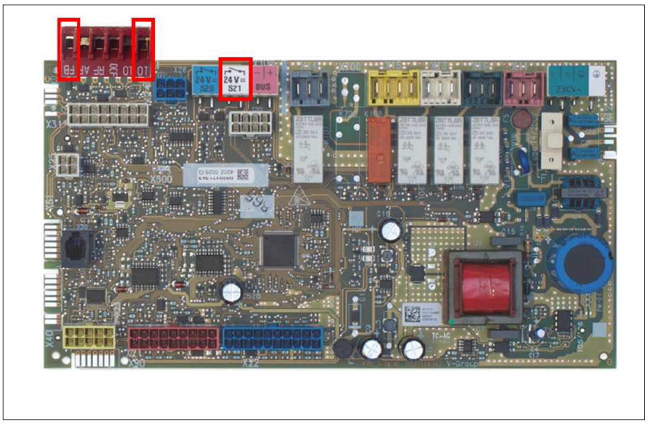


Fig. 80: Control PCB with highlighted energy supply company (ESC) input (S21) and multi-function input (FB and neutral/earth)

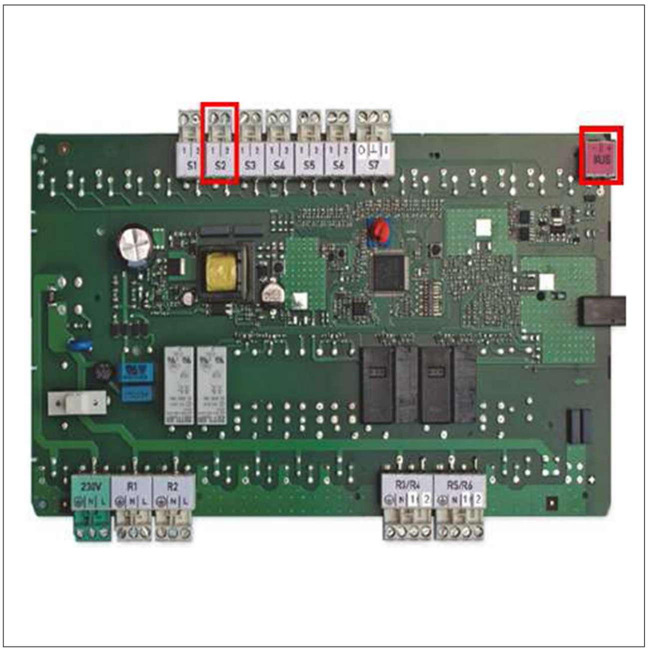


Fig. 81: VR 70 PCB with highlighted S2 input and eBUS connection

5.3.6 Settings in the VRC 700 system control for the flexoTHERM, flexoCOMPACT, aroTHERM and aroTHERM split

- VRC700_1-5576 - Basic system diagram = 8
- VRC700_1-5512 - Configuration: VR 70, addr. 1 = 1
- VRC700_1-7697 - Energy supplier = HP&BH off
- VRC700_1-9784 - Multi-function input = Smart PV
- VRC700_1-9920 - PV buffer cylinder offset = e.g. 10 K
- VRC700_1-7923 - Zone activated = Yes (for zone/HK B)
- VRC700_1-5391 - Type of circuit = Fixed value (for HK A)
- VRC700_1-5391 - Type of circuit = Heating (for HK B)
- VRC700_1-4508 - Outs. temp. switch-off threshold = e.g. 21 °C (identical for both HK A and HK B)
- VRC700_1-5401 - Day target flow temperature = e.g. 50 °C (for HK A)
- VRC700_1-5402 - Night target flow temperature = 0 °C (for HK A)
- VRC700_1-4504 - Operating mode/heating = Day (for zone/HK A)

Further functions are described in the **VRC 700** installation instructions.

Setting in the flexoTHERM/flexoCOMPACT heat pump

Cooling: **Cooling OFF**

5.3.7 Connection to aroSTOR domestic hot water heat pump

Low tariff/high tariff

A low-tariff plug (LT plug) designed as a potential-free switching contact is located on the relay printed circuit board. If the power supply network operator opens this contact, it is possible to set the components which take over cylinder charging in the heat pump menu under the „AUX.SETT." parameter during high-tariff periods (heat pump, back-up heater, none). If a photovoltaic installation is integrated into the system, this function is not available.

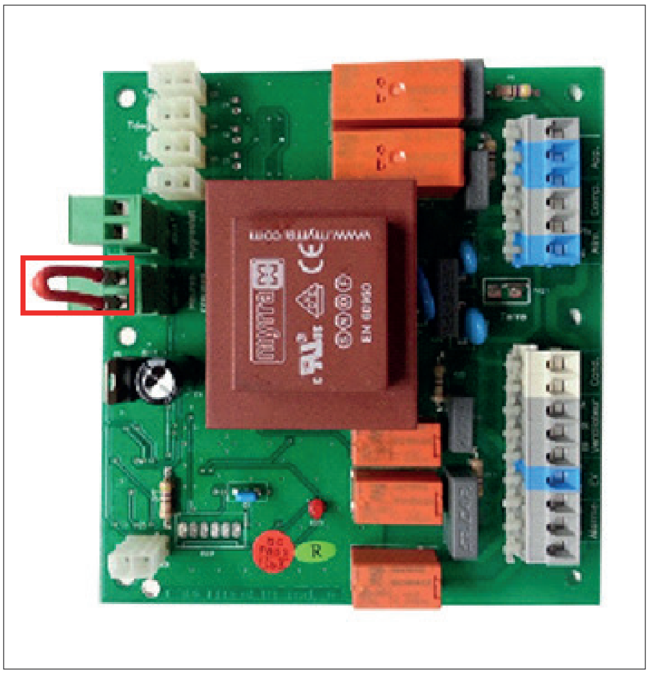


Fig. 82: aroSTOR relay printed circuit board with low-tariff plug

5.3.8 System plans

flexoTHERM and flexoCOMPACT

flexoTHERM VWF 57/4, VWF 87/4, VWF 117/4, VWF 157/4 and VWF 197/4.

flexoCOMPACT VWF 58/4, VWF 88/4 and VWF 118/4.

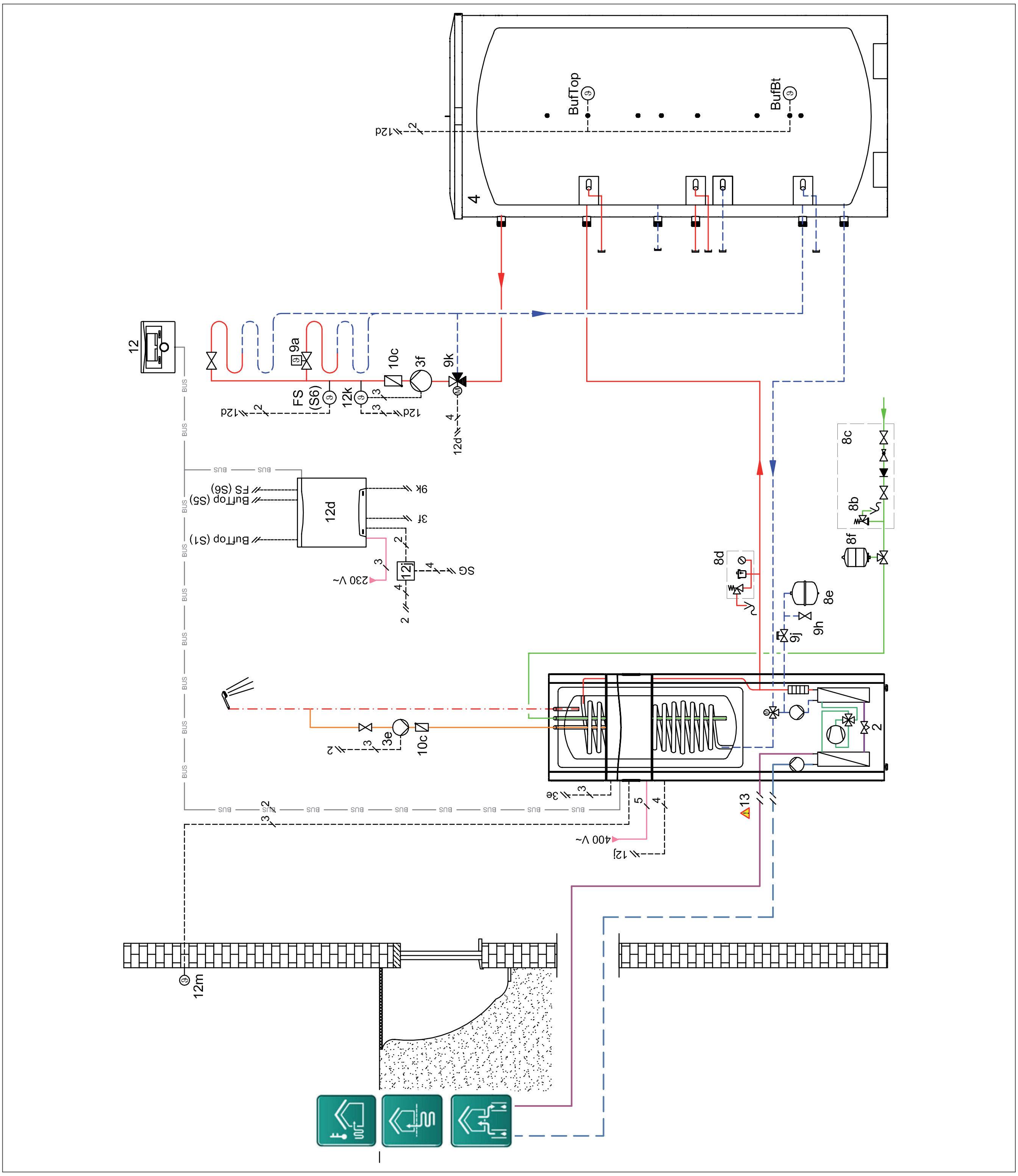


Fig. 83: flexoTHERM/flexoCOMPACT hydraulic plan

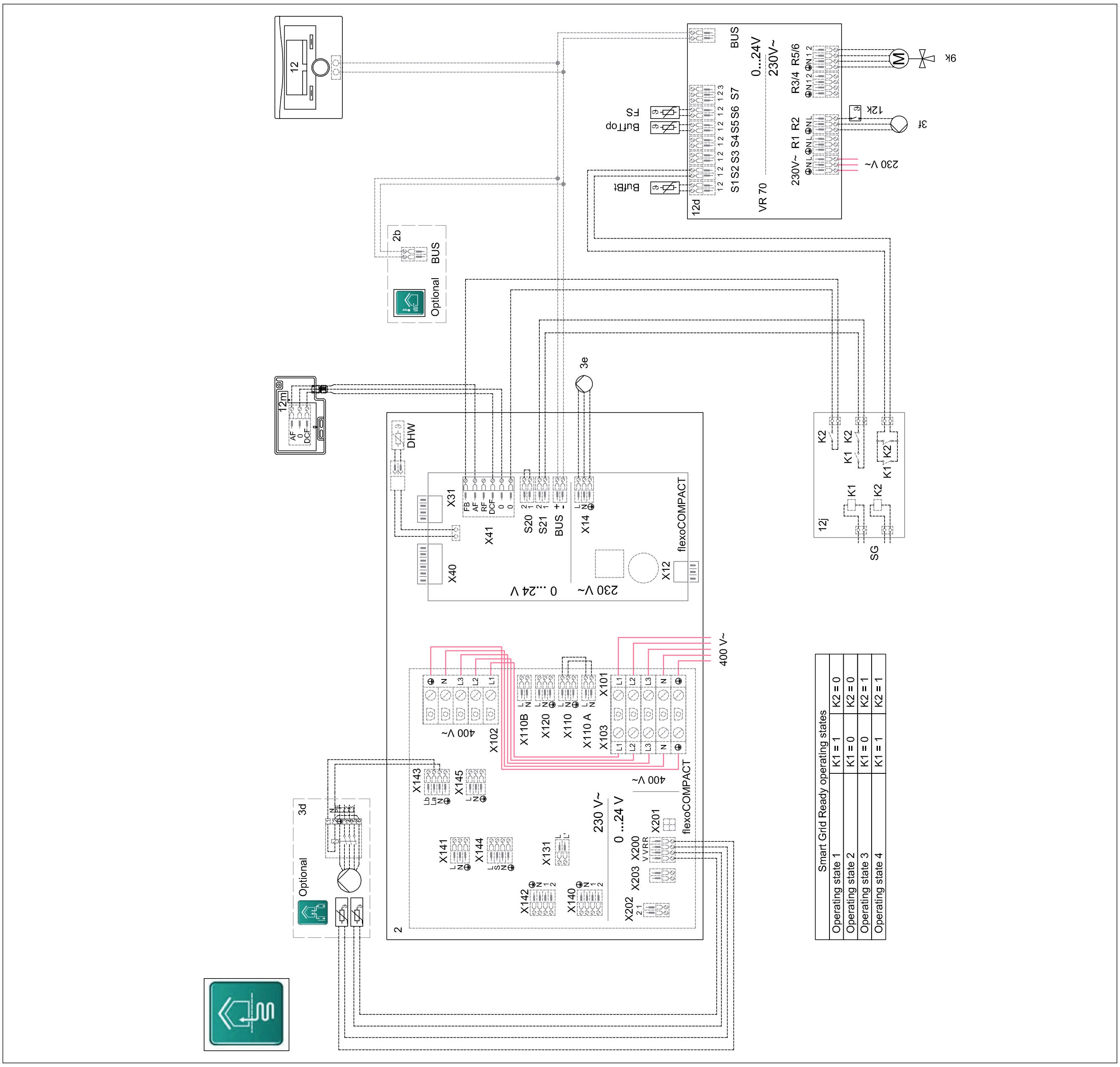


Fig. 84: flexoTHERM/flexoCOMPACT connection diagram

VWL 55/3, VWL 85/3, VWL 115/2 and VWL 155/2.

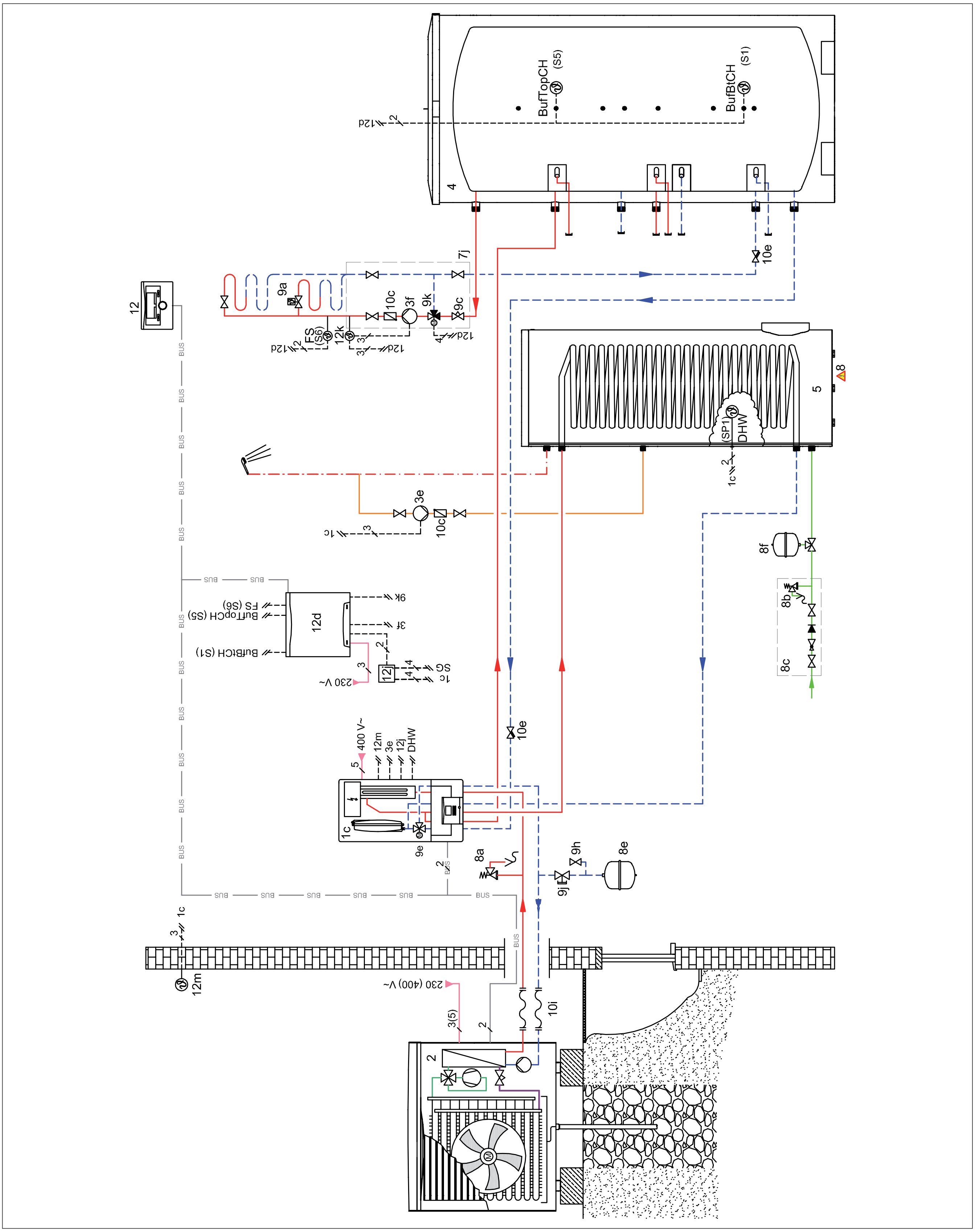
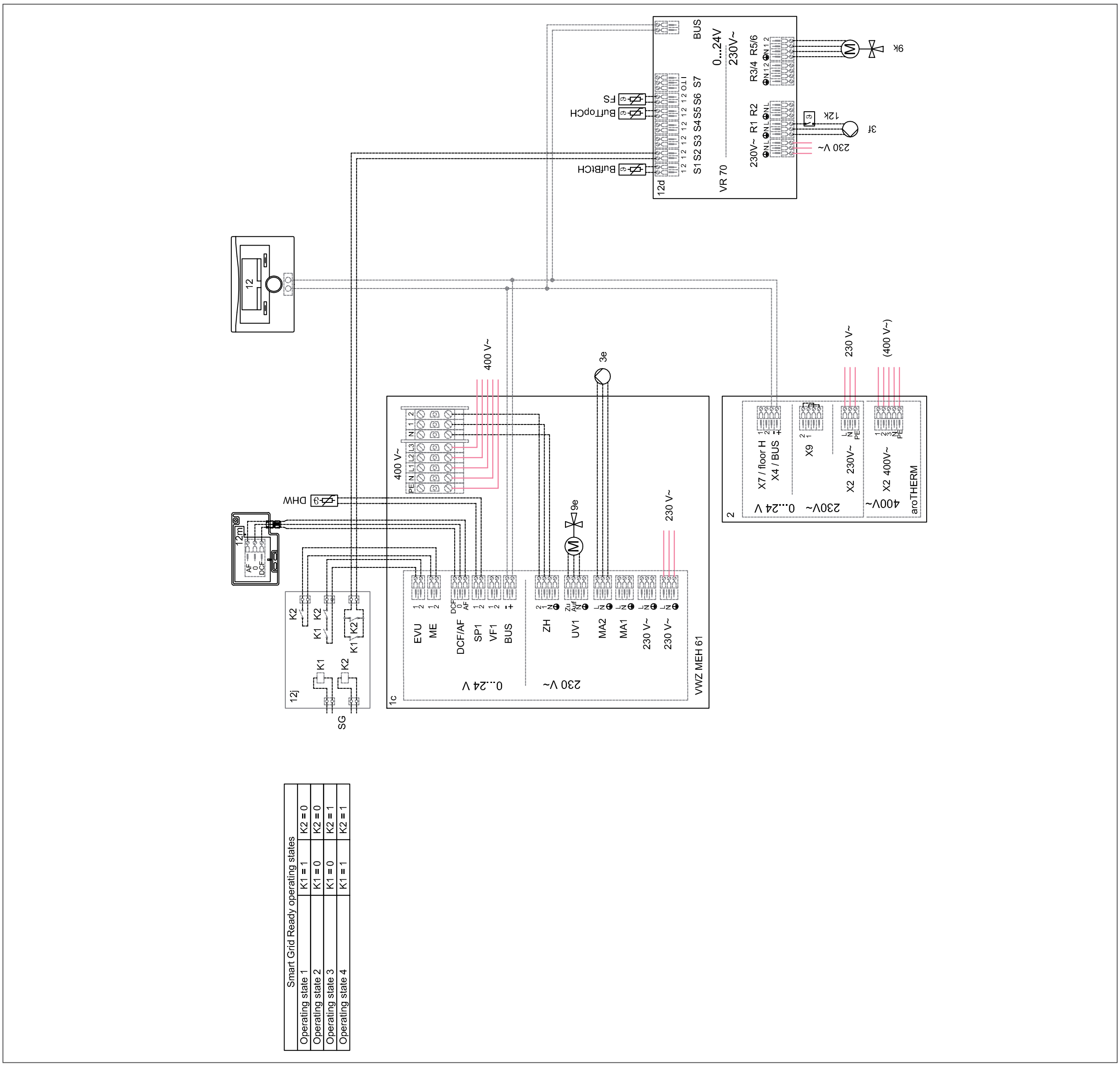


Fig. 85: aroTHERM hydraulic plan



Smart Grid Ready operating states		
Operating state 1	K1 = 1	K2 = 0
Operating state 2	K1 = 0	K2 = 0
Operating state 3	K1 = 0	K2 = 1
Operating state 4	K1 = 1	K2 = 1

Fig. 86: aroTHERM connection diagram

aroTHERM split with hydraulic station

VWL 35/5 AS, VWL 55/5 AS, VWL 75/5 AS, VWL 105/5 AS and VWL 125/5 AS with VWL IS.

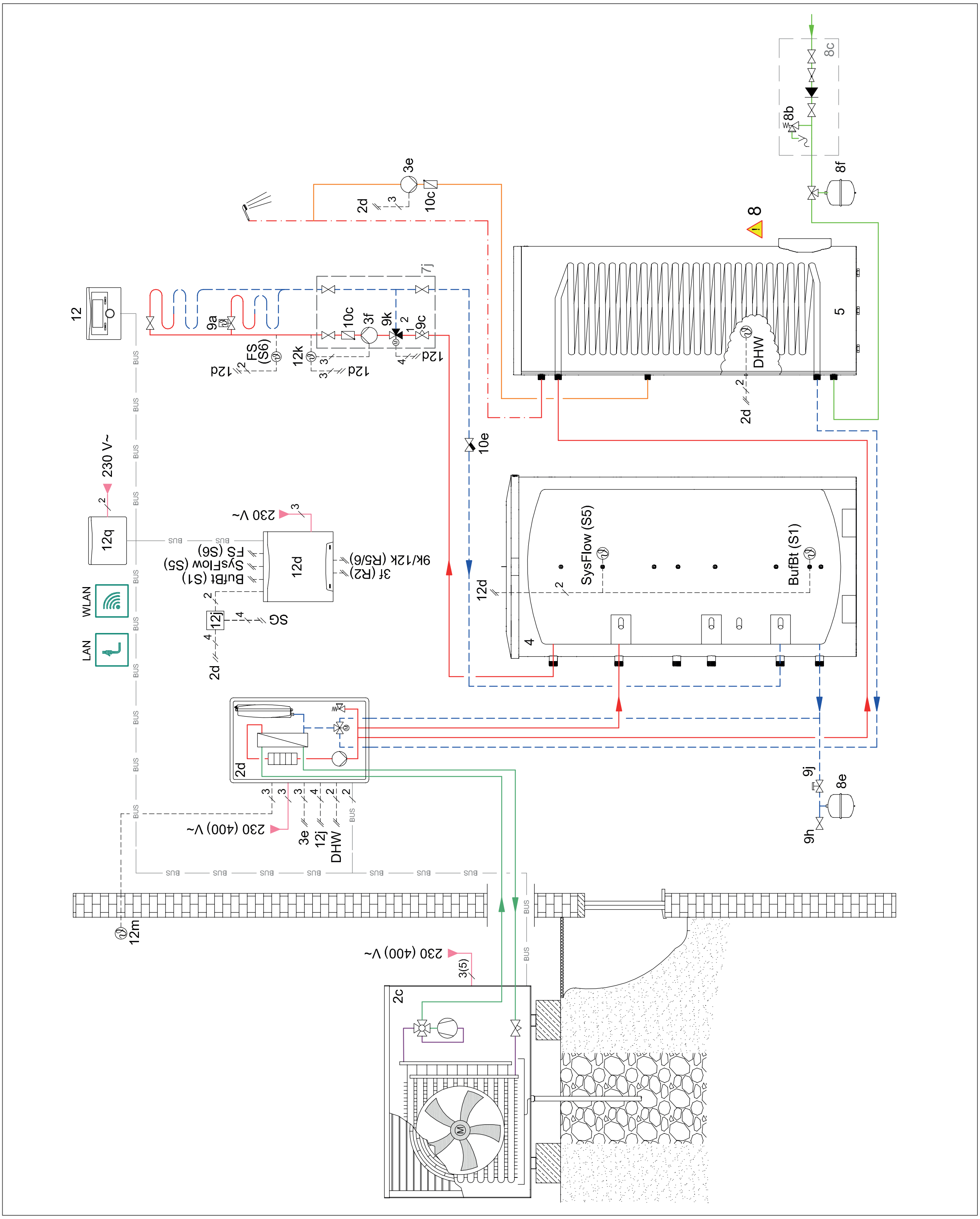


Fig. 87: aroTHERM split hydraulic diagram

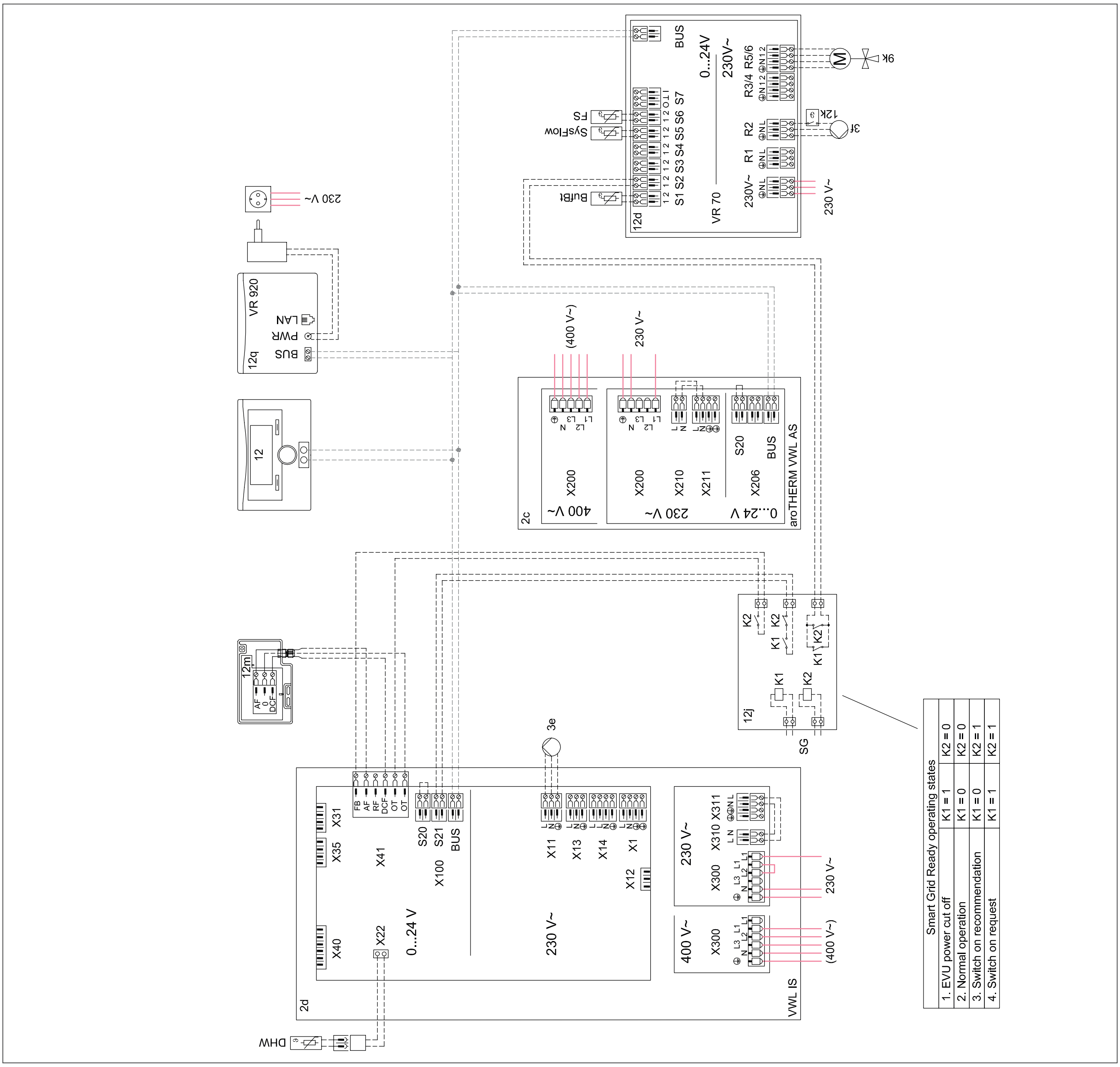


Fig. 88: aroTHERM split connection diagram

5.4 PV Ready

Excess electricity that is generated by the photovoltaic installation can be used for a heat pump. As a result, the solar current is not only used in your own household but, thanks to heat pump technology, it is also simultaneously efficiently converted into heat and stored.

This means that the energy production of the photovoltaic installation is used optimally, and you can use more of the energy you produce yourself.

To actuate the heat pump specifically when there is excess PV energy, the switching statuses 1 and 2 of the PV Ready are used.

5.4.1 Functionality

The switching states 1 and 2 are transmitted to the heating system by an on-site transfer point.

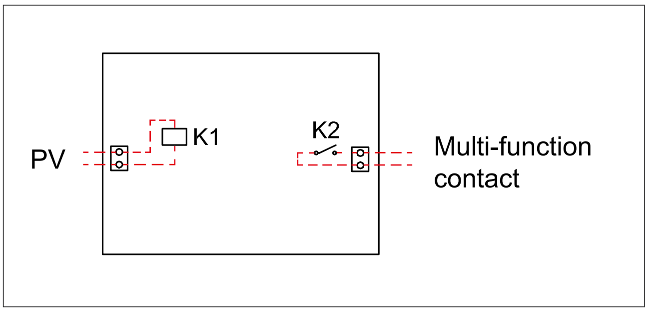


Fig. 89: On-site signal transfer point

Switching status 1 (K1 = 0) – normal mode

Operation: No restriction on heat pump operation.

Switching status 2 (K1 = 1) – switch-on recommendation

Operation: The system stores energy in the domestic hot water cylinder by triggering one-time cylinder charging until the target temperature that is set in the control is reached. The system then stores energy in the buffer cylinder (if available) by increasing the temperature by the target value set in the control. In the case of domestic hot water generation, the forced charging prevails over the time programmes for hot water. Cylinder charging is carried out outside of the set time periods.

If there is no heat requirement and switching status 2 is present, no cylinder charging takes place in heating mode.

5.4.2 Connecting to the flexoTHERM/ flexoCOMPACT exclusive

For the **flexoTHERM/flexoCOMPACT**, the „FB and OT“ contact on plug X 41 is closed by an energy manager in the photovoltaic installation, for example (as of software version 304.03.00). In advance of this, the competent person must set the „multi-function input“ on the VRC 700 to „PV“.

The PV function has been provided since the VRC 700/2. If a VR 70 wiring centre is available in the system, a bridge must be installed at sensor input S2.

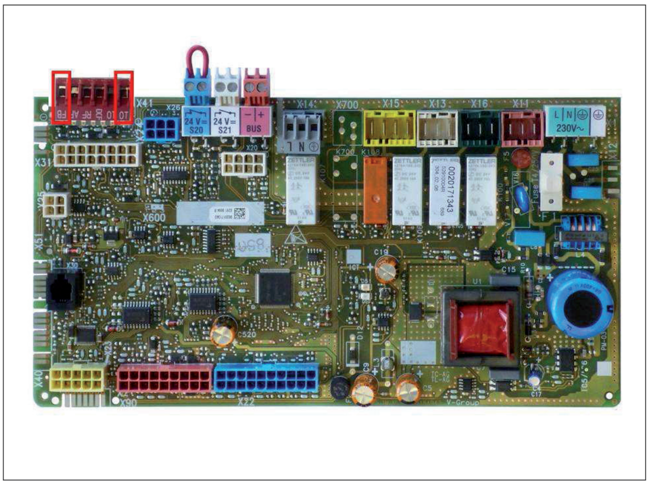


Fig. 90: FB and OT contacts on the PCB

1. Connecting the transfer point to the system as can be seen from the system wiring 0020177918.
2. **Switch-on recommendation:** Connect the N/O contact of K2 to plug X 41 on the FB and OT contacts.
3. **Optional:** If a VR 70 wiring centre is available, install a bridge at sensor input S2.

5.4.3 Connecting to the aroTHERM or geoTHERM

With the **aroTHERM** or **geoTHERM VWS 36/4.1,** the ME multi-functional input with the potential-free contact of the Energy Manager must be connected to the connection PCB of the VWZ MEH 61, the VWZ AI or the VIH QW 190.

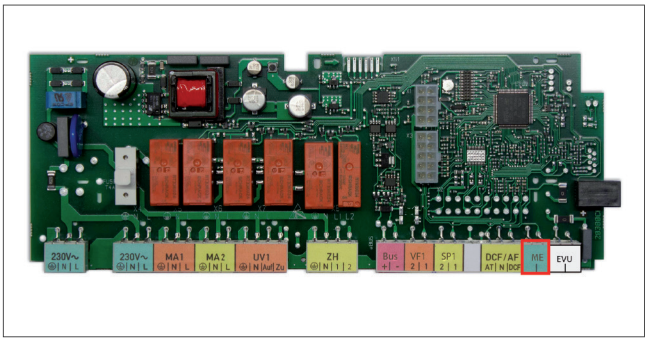


Fig. 91: VWZ MEH 61 – with multi-functional input and energy supply company input

1. Connecting the transfer point to the system as can be seen from the system wiring 0020223729.
2. **Switch-on recommendation:** Connect the N/O contact of K2 to the ME input.

5.4.4 Connection to aroSTOR domestic hot water heat pump

A plug for an external fan control (1) and a low-tariff plug (LT plug) designed as a potential-free switching contact are located on the relay printed circuit board. If these contacts are connected to the photovoltaic installation, two different switching statuses arise.

In doing so, note that only one of the two switching statuses may be used. You cannot connect both statuses to one system.

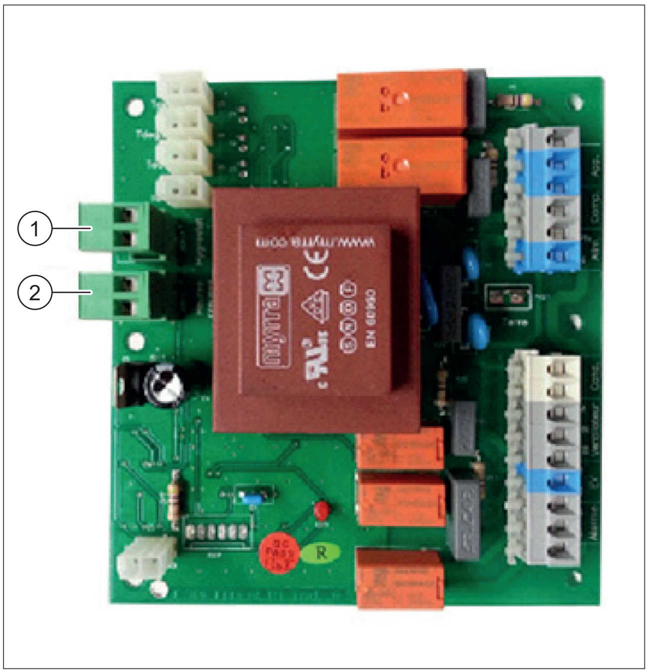


Fig. 92: Relay PCB with external fan control and low-tariff plug

1 External fan control system (compressor and electrical immersion heater)
2 Low-tariff plug (compressor only)

This function can make use of the self-sufficiency optimised by the photovoltaic installation to supply the heat pump and the electrical immersion heater and to heat up the water in the cylinder.

5.4.5 System plans

flexoTHERM and flexoCOMPACT

flexoTHERM VWF 57/4, VWF 87/4, VWF 117/4, VWF 157/4 and VWF 197/4.

flexoCOMPACT VWF 58/4, VWF 88/4 and VWF 118/4.

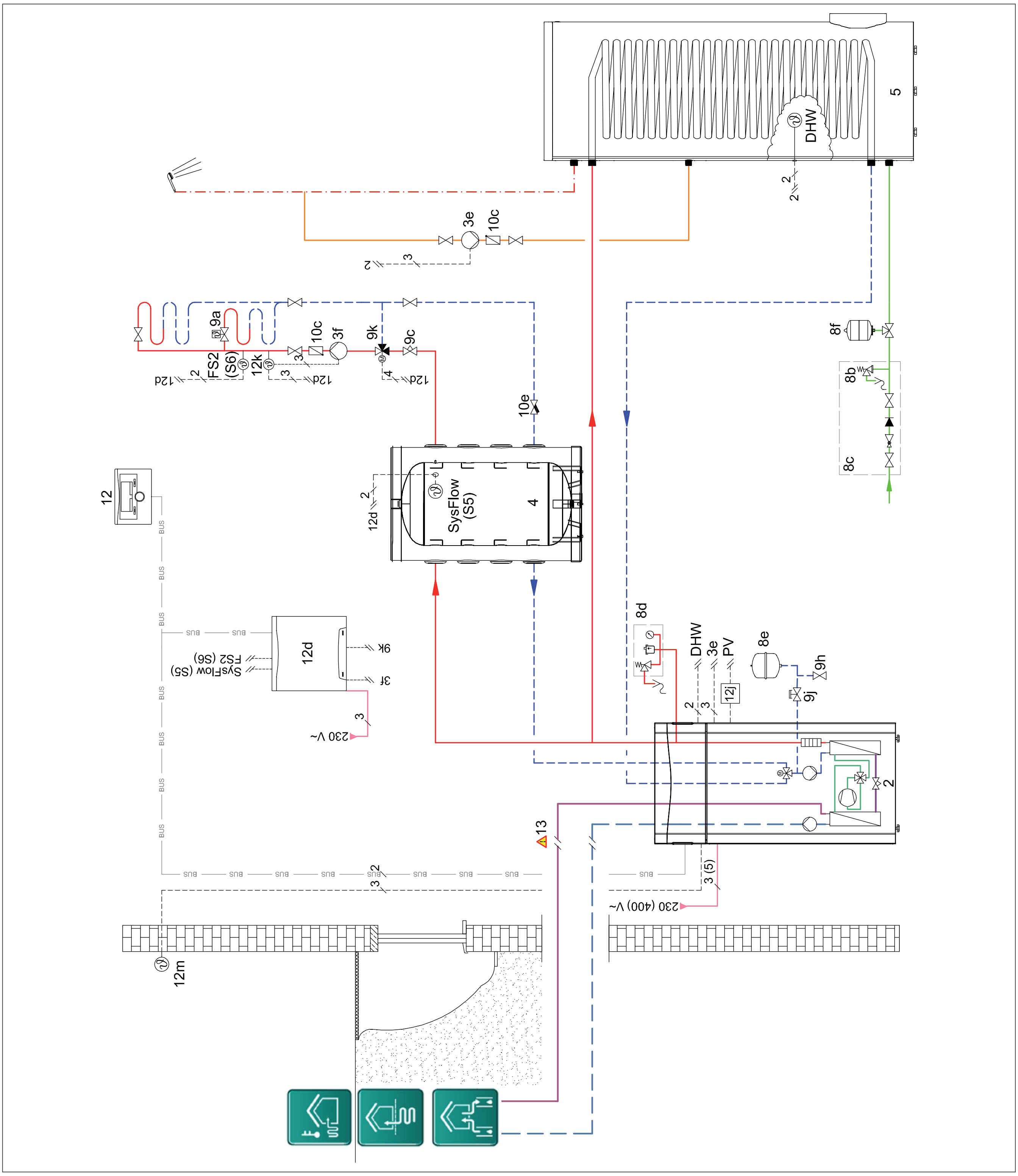


Fig. 93: flexoTHERM/flexoCOMPACT hydraulic plan

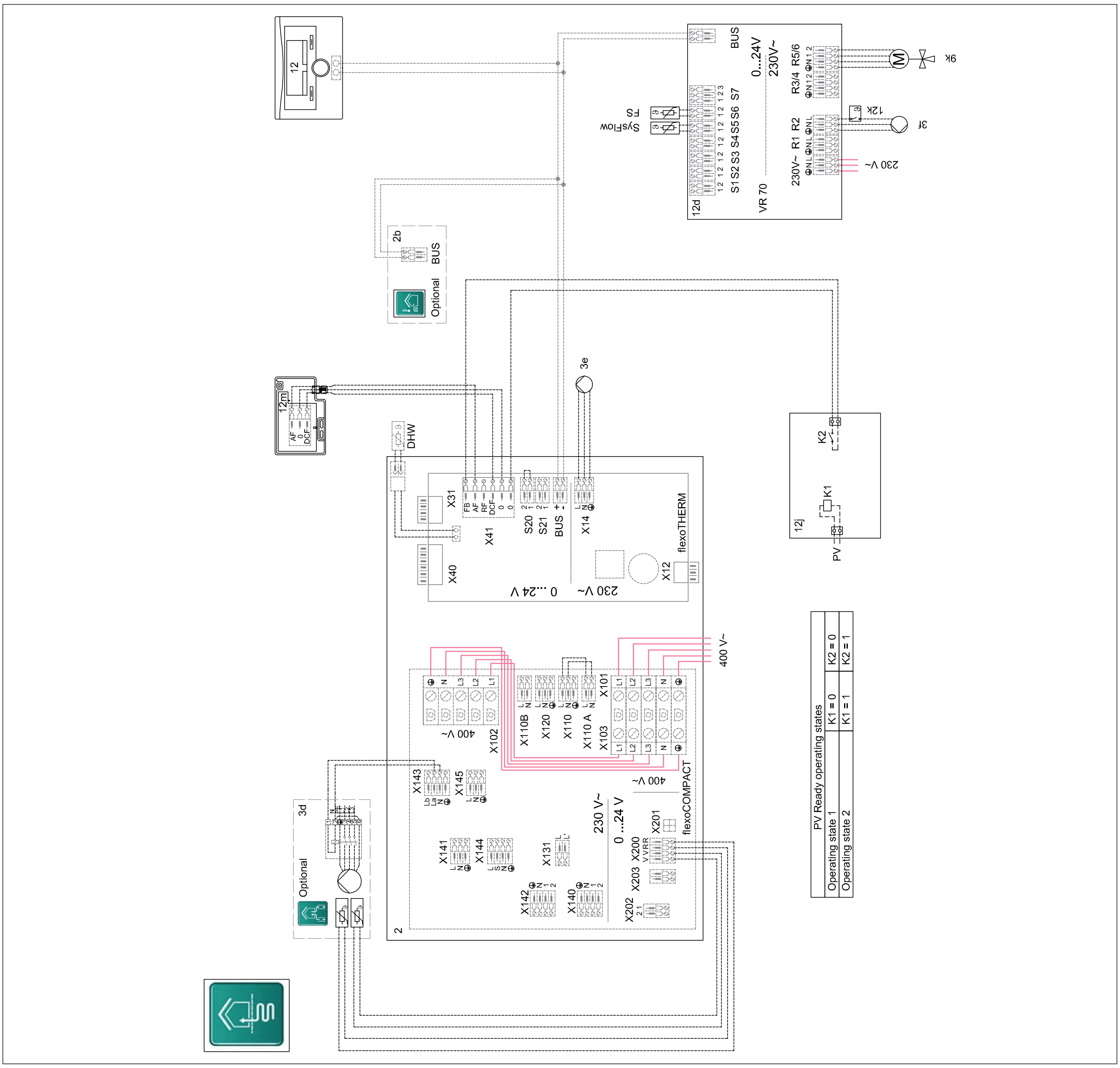


Fig. 94: flexoTHERM/flexoCOMPACT connection diagram

VWL 55/3, VWL 85/3, VWL 115/2 and VWL 155/2.

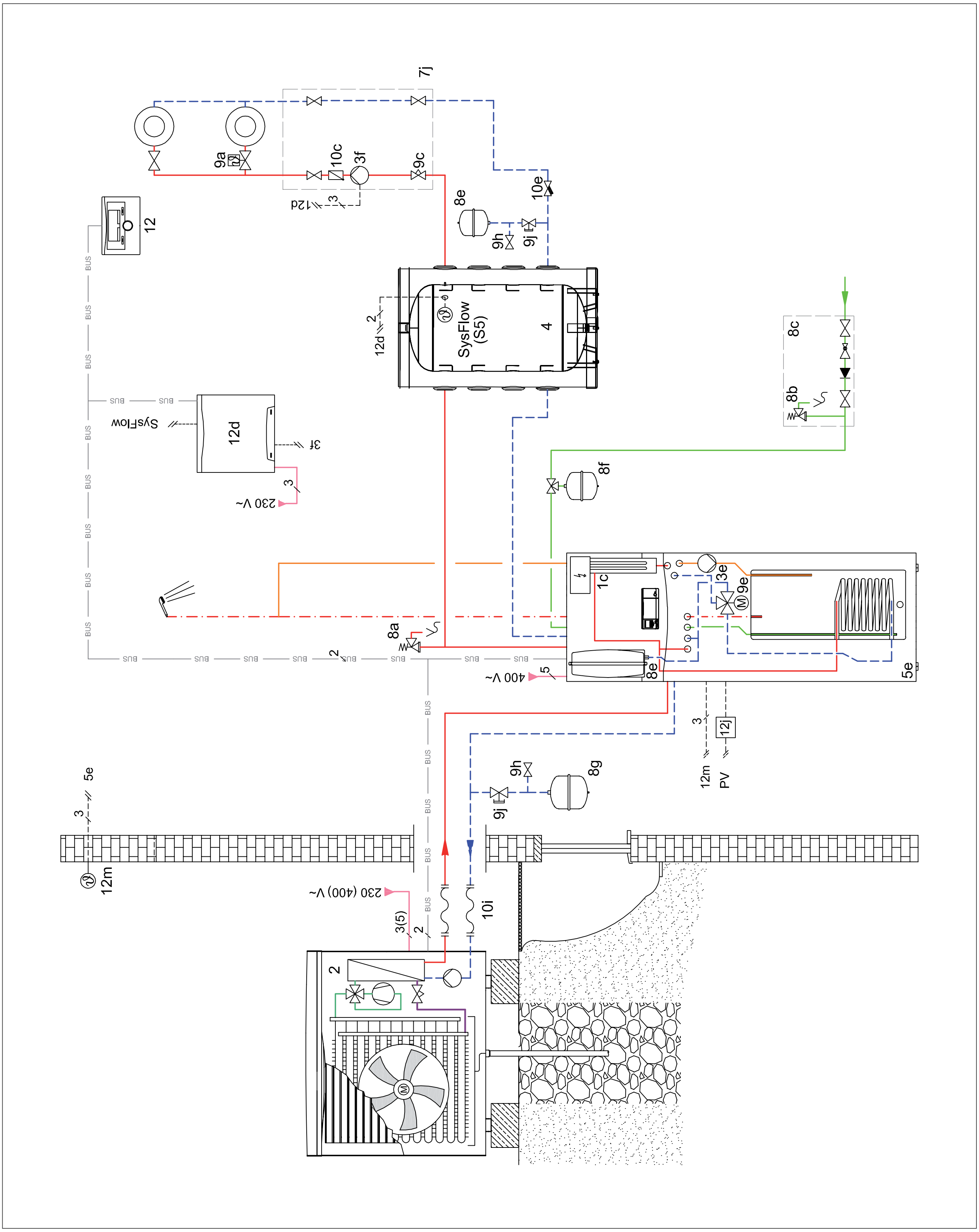


Fig. 95: aroTHERM hydraulic plan

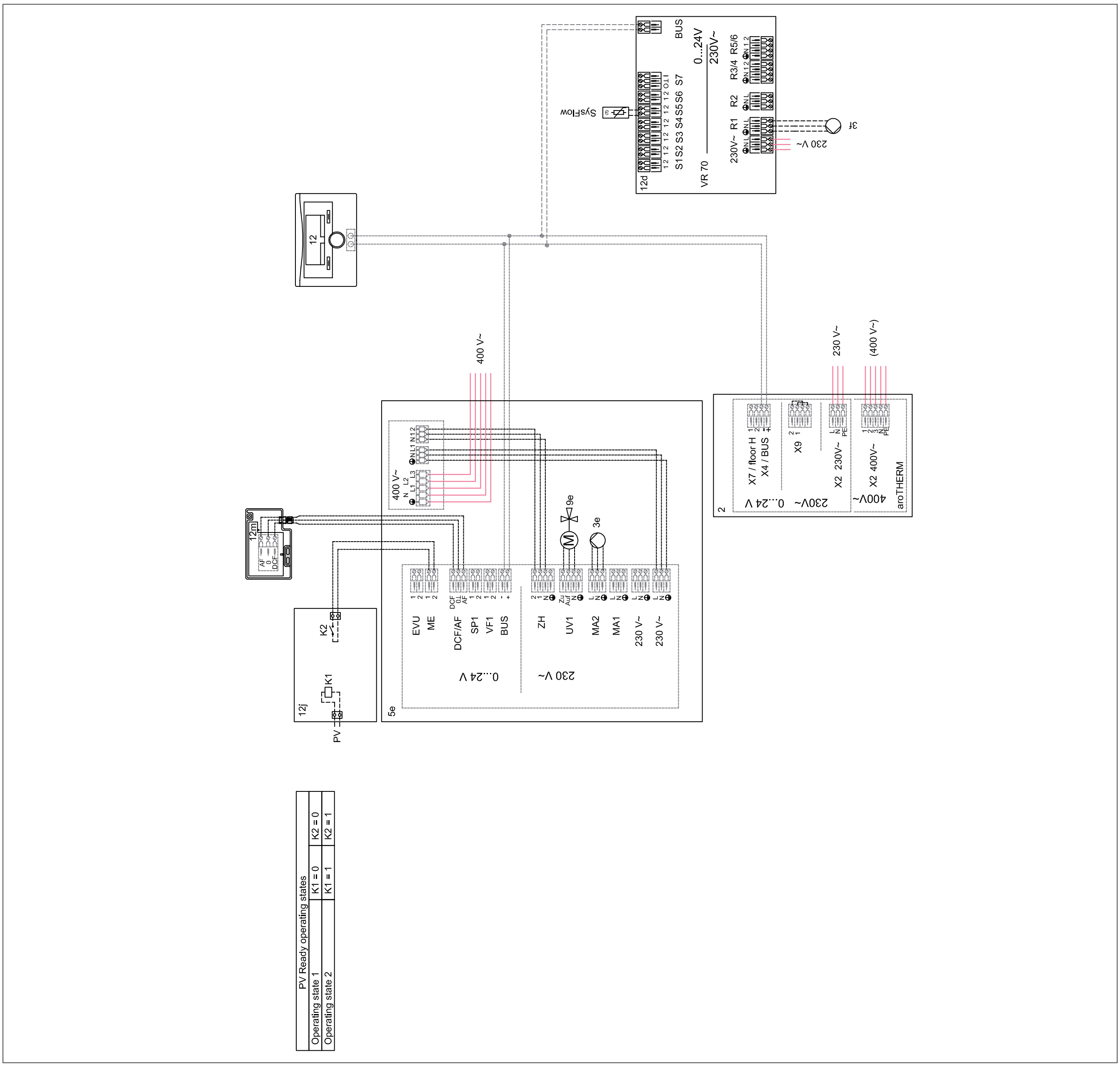


Fig. 96: aroTHERM connection diagram

6. Intelligent system combinations from Vaillant

A system that comprises a heat pump, ventilation, photovoltaics and a battery bank preserves natural resources particularly consistently and complies with the energy requirements for the KfW efficient house 40 Plus.

6.1 Intelligent system combinations from Vaillant

Since Vaillant heat pumps are „SG Ready“, they can also be integrated into intelligent power grids (Smart Grids). This means that self-supplied photovoltaic electricity and intelligent energy management guarantee extremely low electricity costs.

Vaillant will not only help you to select and plan the right heating system for your needs, but also offer you considerable assistance with system start-up and maintenance.

6.1.1 aroTHERM – in combination with uniTOWER

Use of the **aroTHERM** heat pump ensures economical exploitation of air as a heat source through simple and easy installation of the heat pump outdoors. In this system configuration, mono-energy mode operation of the heat pump is possible.

In the system configuration below, the heat pump is combined with the **uniTOWER**. Two heating circuits are supplied with heat via the hydraulic components in the **uniTOWER**, in this case specially via the installation and extension sets (1 x low loss header, 1 x heating circuit with mixer, 1 x heating circuit without mixer).

The heat pump charges the cylinder, if necessary with the support of the electric back-up heater that is integrated in the **uniTOWER**. The **VRC 700** system control (wall-hung) controls the heat pump system. Since **VRC 700/2**, PV Ready functions have been possible.

The **recoVAIR** domestic ventilation unit can be combined with all heating systems for controlled ventilation with heat recovery.

The photovoltaic system is equipped with a digital electricity meter for dynamic feed-in management and the feed-in management wiring centre. It is therefore possible to operate the heat pump via the photovoltaic system.

Key system components:

- Boiler: **aroTHERM** heat pump
- **recoVAIR** domestic ventilation unit
- **uniTOWER** compact unit with domestic hot water cylinder and components for heat distribution
- Photovoltaic system: **auroPOWER** PV modules, **auroPOWER** inverter, three-phase electricity meter with RTU Modbus connection cable and feed-in management wiring centre
- **VRC 700** weather-compensated control for heating, cooling, ventilation and domestic hot water generation

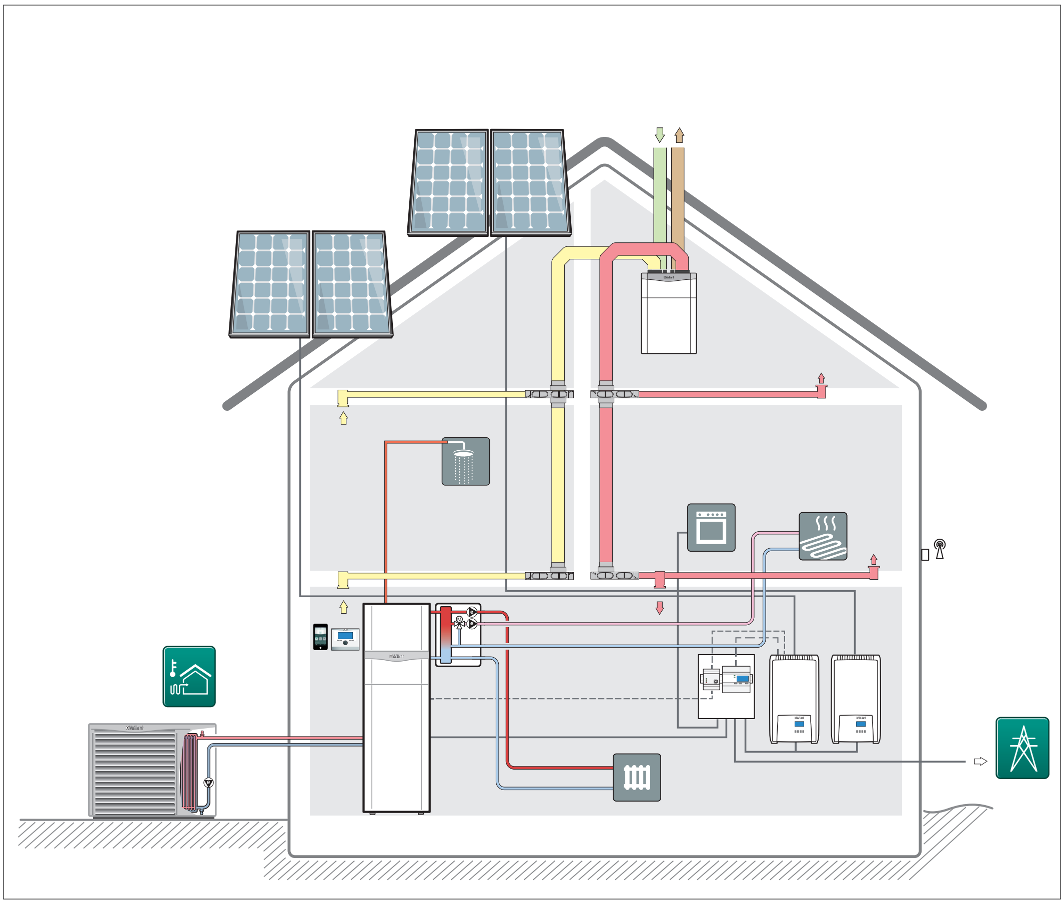


Fig. 97: aroTHERM – in combination with uniTOWER

The VRC 700 weather-compensated heating control is used to control and adjust the heat pump system.

6.1.2 flexoCOMPACT heat pump installation

The **flexoCOMPACT exclusive** heat pumps are easy to install. The hot water comfort is determined by the integrated 171 l domestic hot water cylinder. It is therefore very important to carefully calibrate this with the required domestic hot water demand in advance. This space-saving solution can be used particularly in new builds without a cellar.

The **recoVAIR** domestic ventilation unit can be combined with all heat pump systems for controlled ventilation with heat recovery.

The photovoltaic system is equipped with a digital electricity meter for dynamic feed-in management and the feed-in management wiring centre. It is therefore possible to operate the heat pump using the battery bank and the photovoltaic system.

Key system components:

- Boiler: **flexoCOMPACT** heat pump
- **recoVAIR** domestic ventilation unit
- Photovoltaic system: **auroPOWER** PV modules, **auroPOWER** inverter, three-phase electricity meter with RTU Modbus connection cable and feed-in management wiring centre
- **eloPACK** battery storage system
- **VRC 700** weather-compensated control for heating, cooling, ventilation and domestic hot water generation
- **VR 920** Internet communication module
- App control for Android and iOS
- Hydraulic assemblies

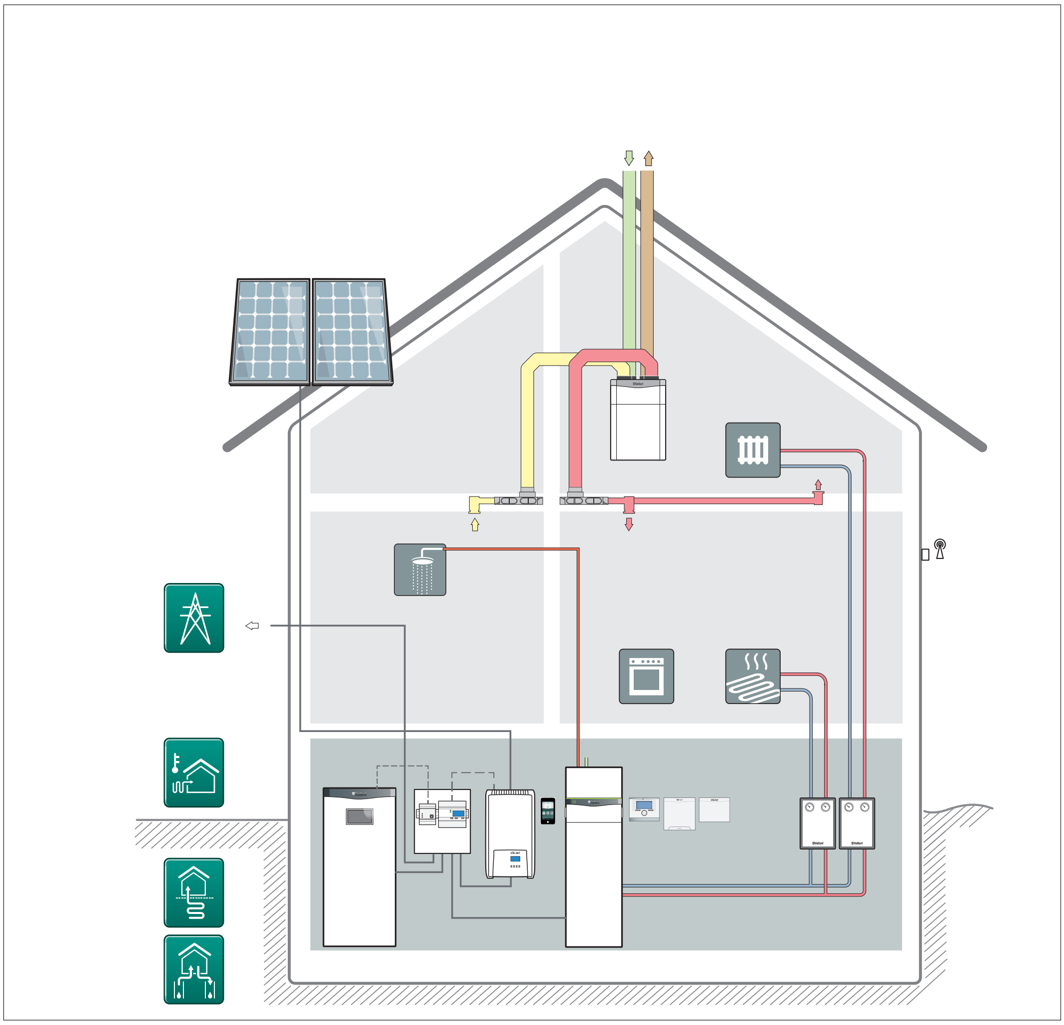


Fig. 98: flexoCOMPACT heat pump installation with eloPACK battery storage system and recoVAIR domestic ventilation

The solution shown above is compatible with all heat sources. The cooling function is available for all heat sources. Information on the different heat sources, their advantages and disadvantages, and the corresponding application limits are summarised in the heat pump's planning module.

6.1.3 Domestic hot water heat pumps in existing installations

The **aroSTOR** domestic hot water heat pump can supply an entire house with domestic hot water from a central location.

The installation room is primarily located where heat accumulates. This may be in a utility room, boiler room or in cellar rooms where waste heat from washing machines or cooling appliances is available. The heat pump extracts the air, cools it and releases it into the room again. The room air is also dehumidified.

The **recoVAIR** domestic ventilation unit can be combined with all heat pump systems for controlled ventilation with heat recovery.

The photovoltaic system is equipped with a digital electricity meter for dynamic feed-in management and the feed-in management wiring centre. It is therefore possible to operate the domestic hot water heat pump via the photovoltaic system.

Key system components:

- **aroSTOR** domestic hot water heat pump
- **ecoTEC** gas-fired condensing boiler
- **recoVAIR** domestic ventilation unit
- Photovoltaic system: **auroPOWER** PV modules, **auroPOWER** inverter, three-phase electricity meter with RTU Modbus connection cable and feed-in management wiring centre

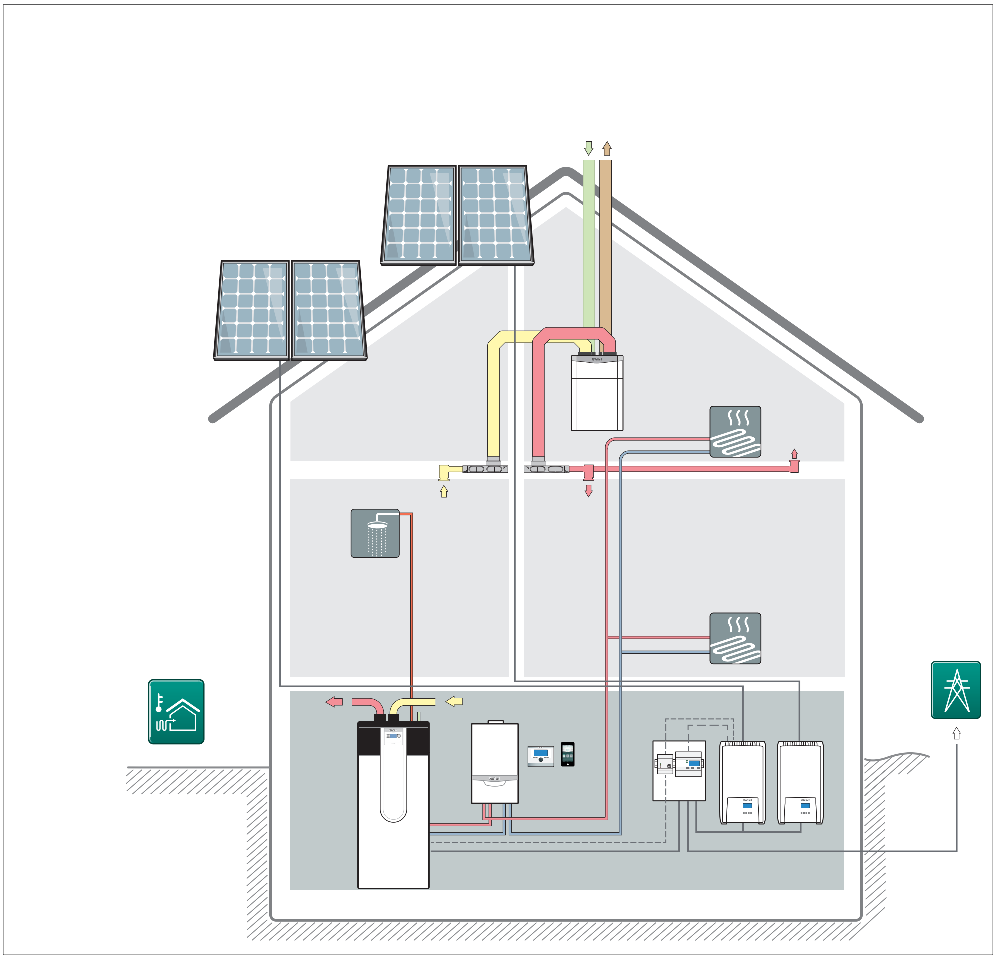


Fig. 99: aroSTOR domestic hot water heat pump for expanding existing installations

The **aroSTOR** VWL B 290/4 and VWL BM 290/4 are designed as standard in such a way that both the supply air and the extract air are extracted from or released into the installation room.

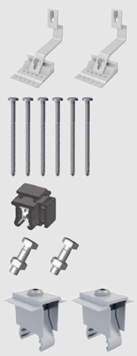
This cools the air in the installation room. If this is not required, the extract air can be guided outdoors via an extract air duct or into another room to be cooled.

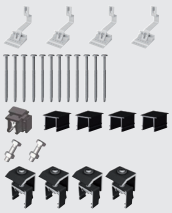
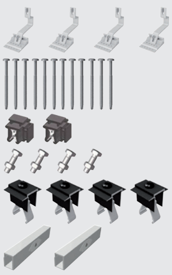
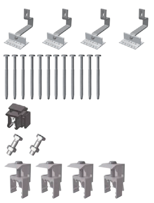
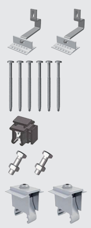
6.2 Photovoltaic system accessories

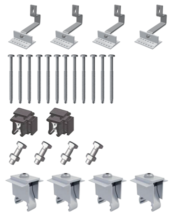
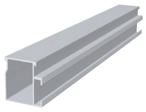
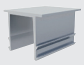
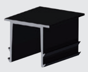
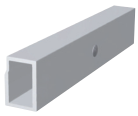
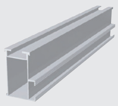
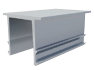
Accessories for feed-in management, cables and DC plug connectors

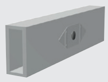
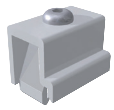
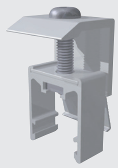
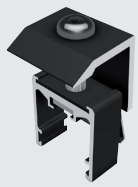
Accessories	Designation	Order no.
	Feed-in management wiring centre for the **auroPOWER VPV I** inverter The wiring centre has a potential-free switching contact for intelligent peak load shifting. This contact can, for example, be used to actuate the PV Ready function on Vaillant heat pumps from the **flexoTHERM**, **flexoCOMPACT**, **aroTHERM** and **aroSTOR** ranges. In addition, the wiring centre can be used for four-stage power reduction in photovoltaic systems.	0020252793
	Three-phase electricity meter for dynamic feed-in management The energy meter can be combined with VPV I series inverters directly via an RTU Modbus (RS 485) interface. In combination with the energy meter, consumption within the building can be measured and dynamic feed-in management can take place. **Note: Order the RTU Modbus (0020228555) connection pipe separately.**	0020252794
No figure	RTU Modbus connection pipe (RS 485) for dynamic feed-in management with the **eloPACK VSE** **Note: The three-phase electricity meter (0020252794) has to be ordered separately**	0020228555
	Electrical immersion heater in combination with a photovoltaic system Heat output 0.5-3.5 kW/1N PE ~ 230 V, 16 A, controlled by the supplied Energy Manager (depending on the photovoltaic excess) **Note: Suitable for increasing the own-consumption rate of PV installations in combination with VIH R 300-500/3, VIH S 300-500/3, VIH RW 300- 500/3, VIH SW 400-500/3**	0020230738
	Pair of DC plug connectors, toolless for connecting the VPV P with the DC cable (one pair)	0020253028
	DC cable, 100 m, 6 mm², without plug for connecting modules and inverters (100 m)	0020062076

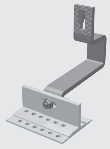
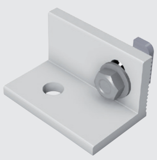
On-roof installation fixing material

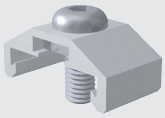
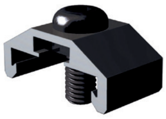
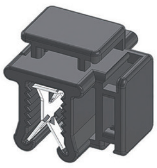
Accessories	Designation	Order no.
Fixing material/on-roof sets (parallel with the roof)		
	Basic set, pitched roof, silver For installing 1 x PV module, silver frame 4 x roof hook, standard, height-adjustable 12 x wood screw, stainless steel, A2, TX 30, 6 x 80 1 x fastening clip with cable tie to secure the DC cable 2 x anti-slip guard for pitched roof 4 x end clamp, adjustable, 30-50 mm, silver 4 x end cap for mounting rail, 40 x 37.1, silver **Note: Aluminium rail, 40 x 37 mm, length 2080 mm for installing PV module, silver (0020228532), order separately**	0020275994
	Expansion set + 1 pitched roof, silver For installing 1 x PV module, silver frame 2 x roof hook, standard, height-adjustable 6 x wood screw, stainless steel, A2, TX 30, 6 x 80 1 x fastening clip with cable tie to secure the DC cable 2 x anti-slip guard, for pitched roof 2 x middle clamp, adjustable, 30-50 mm, silver **Note: Mounting rail, 40 x 37 mm, length 2080 mm for installing PV module, silver (0020228532), order separately.**	0020275997

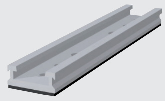
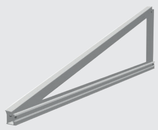
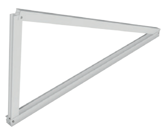
Accessories	Designation	Order no.
	Expansion set + 2, pitched roof, silver For installing 2 x PV module, silver frame 4 x roof hook, standard, height-adjustable 12 x wood screw, stainless steel, A2, TX 30, 6 x 80 2 x fastening clip with cable tie to secure the DC cable 4 x anti-slip guard, for pitched roof 4 x middle clamp, adjustable, 30-50 mm, silver 2 x rail connectors with potential equalisation for mounting rail, 40 x 37 mm **Note: Aluminium rail, 40 x 37 mm, length 2080 mm for installing PV module, silver (0020228532), order separately**	0020275998
	Basic set, pitched roof, black for installing 1 x PV module, black frame 4 x roof hook, standard, height-adjustable 12 x wood screw, stainless steel, A2, TX 30, 6 x 80 1 x fastening clip with cable tie to secure the DC cable 2 x anti-slip guard, for pitched roof 4 x end clamp, adjustable, 30-50 mm, black 4 x end cap for mounting rail, 40 x 37.1, black **Note: Aluminium rail, 40 x 37 mm, length 2080 mm for installing PV module, black (0020228542), order separately**	0020276000
	Expansion set + 1, pitched roof, black For installing 1 x PV module, black frame 2 x roof hook, standard, height-adjustable 6 x wood screw, stainless steel, A2, TX 30, 6 x 80 1 x fastening clip with cable tie to secure the DC cable 2 x anti-slip guard, for pitched roof 2 x middle clamp, adjustable, 30-50 mm, black **Note: Aluminium rail, 40 x 37 mm, length 2080 mm for installing PV module, black (0020228542), order separately**	0020276004
	Extension set + 2, pitched roof, black For installing 2 x PV module, black frame 4 x roof hook, standard, height-adjustable 12 x wood screw, stainless steel, A2, TX 30, 6 x 80 2 x fastening clip with cable tie to secure the DC cable 4 x anti-slip guard, for pitched roof 4 x middle clamp, adjustable, 30-50 mm, black 2 x rail connectors with potential equalisation for mounting rail, 40 x 37 mm **Note: Aluminium rail, 40 x 37 mm, length 2080 mm for installing PV module, black (0020228542), order separately**	0020276003
	Pitched roof set, silver, heavy load Basis for installing 1 x VPV P, silver frame 4 x roof hook, heavy load, height-adjustable 12 x wood screw, stainless steel, A2, TX 30, 6 x 100 1 x fastening clip with cable tie to secure the DC cable 2 x anti-slip guard for pitched roof 4 x end clamp, adjustable, 30-50 mm, silver **Note: Aluminium rail, length 2080 mm for installing the PV module**	0010029482
	Pitched roof set, silver, heavy load, Extension + 1 for installing 1 x VPV P, silver frame 2 x roof hook, heavy load, height-adjustable 6 x wood screw, stainless steel, A2, TX 30, 6 x 100 1 x fastening clip with cable tie to secure the DC cable 2 x anti-slip guard, for pitched roof 2 x middle clamp, adjustable, 30 mm-50 mm, silver **Note: Aluminium rail, length 2080 mm for installing the PV module**	0010029484

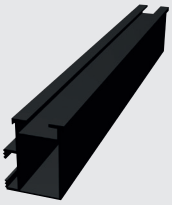
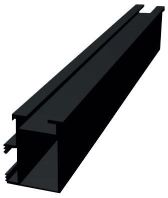
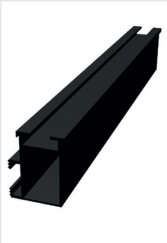
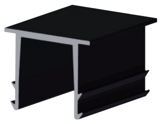
Accessories	Designation	Order no.
	Pitched roof set, silver, heavy load, Extension + 2 for installing 2 x VPV P, silver frame 4 x roof hook, heavy load, height-adjustable 12 x wood screw, stainless steel, A2, TX 30, 6 x 100 2 x fastening clip with cable tie to secure the DC cable 4 x anti-slip guard, for pitched roof 4 x middle clamp, adjustable, 30 mm - 50 mm, silver **Note: Aluminium rail, length 2080 mm for installing the PV module**	0010029483
Fixing material/on-roof individual components (parallel with the roof)		
	Mounting rail, 40 x 37 mm, length 2080 mm for installing PV module, silver (1 pc) Can be used when installing on on-site mounting supports or rafter anchors. Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 5.078 cm^4 Max. moment of resistance Wx = 2.501 cm^3 Dimensions (H x W x L) 40 x 37.1 x 2080 mm Weight 1.275 kg/pc No hammer head duct on the top of the rail	0020228532
	Mounting rail, silver, end caps, 40 x 37.1 mm (4 pcs) For sealing the mounting rails Aluminium EN-AW-6063 T6 Dimensions (H x W x L) 31 x 25 x 36.8 mm Weight 0.013 kg/pc Can be used for auroPOWER VPV P	0020271103
	Mounting rail, 40 x 37.1 mm, length 2080 mm for installing PV module, black (1 pc) Can be used when installing on on-site mounting supports or rafter anchors. Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 5.078 cm^4 Max. moment of resistance Wx = 2.501 cm^3 Dimensions (H x W x L) 40 x 37.1 x 2080 mm Weight 1.275 kg/pc No hammer head duct on the top of the rail	0020228542
	Mounting rail, black, end caps, 40 x 37.1 mm (4 pcs) For sealing the mounting rails Aluminium EN-AW-6063 T6 Dimensions (H x W x L) 31 x 25 x 36.8 mm Weight 0.013 kg/pc Can be used for auroPOWER VPV P	0020271104
	Rail connectors with potential equalisation for mounting rail, 40 x 37 mm (10 pcs) For connecting the mounting rails for installation on on-site solar brackets or rafter anchors. Can be used for PV modules. Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 5.594 cm^4 Max. moment of resistance Wx = 2.910 cm^3 Dimensions (H x W x L) 37.1 x 25.6 x 195 mm Weight 0.174 kg/pc incl. push-through protection	0020273246
	Mounting rail, silver, 60 x 37.1 x 2080 mm, (1 pc) for installing VPV P Can be used when installing on on-site mounting supports or rafter anchors Aluminium EN-AW-6063 T6 Max. torque of inertia I x 14.622 cm^4 Max. moment of resistance W x 4.815 cm^3 Dimensions (H x W x L) 60 x 37.1 x 2080 mm Weight 3,613 kg/pc	0010029474
	Mounting rail, silver, end caps, 60 x 37.1 mm (4 pcs) For sealing the mounting rails Aluminium EN-AW-6063 T6 Dimensions (H x W x L) 31 x 25 x 48.2 mm Weight 0.017 kg/pc Can be used for auroPOWER VPV P	0010029477

Accessories	Designation	Order no.
	Mounting rail, connector, 60 x 37.1 mm, (2 pcs), with potential equalisation To extend the mounting rails Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 13.084 cm^3 Max. moment of resistance Wx 5.395 cm^3 Dimensions (H x W x L) 48.5 x 23.8 x 195 mm Weight 0.256 kg/pc incl. push-through protection Can be used for auroPOWER VPV P	0010029476
	Cross rail connectors for aluminium rail, 40 x 37.1 mm and 47 x 35.4 mm (20 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection, X5Cr-Ni18-10 A2-70 Weight 0.048 kg/pc Pre-installed **Note: 1 pc per crossing point**	0020228545
	End clamp, adj. 30-50 mm, silver For module fixing on a mounting rail (10 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection, X5CrNi18-10 A2-70 A Module frame height from 30 mm to 50 mm Clamp distance 25 mm Weight 0.055 kg/pc Pre-installed	0020276014
	Middle clamp, adj. 30-50 mm, silver for module fixing on an aluminium rail (40 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection, X5CrNi18-10 A2-70 A Module frame height from 30 mm to 50 mm Clamp distance 19 mm between the modules Weight 0.048 kg/pc Pre-installed	0020228552
	End clamp, adj. 30-50 mm, black For module fixing on a mounting rail (10 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Module frame height from 30 mm to 50 mm Clamp distance 25 mm Weight 0.055 kg/pc Pre-installed	0020276023
	Middle clamp, adj. 30-50 mm, black For module fixing on a mounting rail (40 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Module frame height from 30 mm to 50 mm Clamp distance 19 mm between the modules Weight 0.048 kg/pc Pre-installed	0020228548
	Earthing plate for middle clamps For establishing the potential equalisation (40 pcs) The earthing plate produces an electrically conductive connection between the module frame and the mounting rail. Stainless steel 1.4301 Weight 0.007 kg/pc Can be used for PV modules	0020271102
	Roof hook, standard, height-adjustable, 45-58 mm With hammer-head screw (10 pcs) Aluminium EN-AW-6082 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 93 mm x 95 mm x 40 mm base plate 10 x 7 mm hole Tile and brick roof shape Max. height compensation 45 to 58 mm in the roof batten area, 21 mm in the rail area Weight 0.446 kg/pc Pre-installed Incl. M8 x 25 hammer head screw set Can be adjusted in three axes **Note: Universal roof hook for almost all common roof tiles**	0020228531

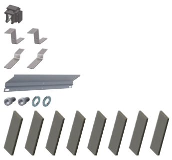
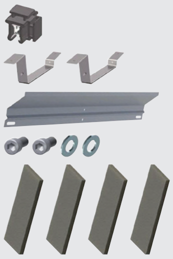
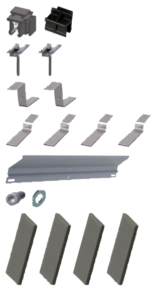
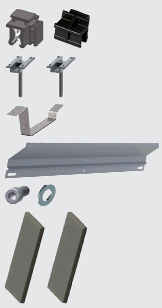
Accessories	Designation	Order no.
	Roof hook, heavy load, adjustable, 49-65 mm (2 pcs) With hammer-head screw Aluminium EN AW-6063 T6 (EN AW-AlMg0,7Si) Stainless steel screwed connection X5CrNi18-10 A2-70 112.5 mm x 84 mm base plate 8 x 7 mm and 8 x 9 mm hole Tile and brick roof shape Weight 0.952 kg/pc Pre-installed Incl. M8 x 25 hammer head screw set Can be adjusted in three axes Can be used for auroPOWER VPV P	0010029479
	Roof hook, stainless steel, slate for slate roofing (10 pcs) Stainless steel A2; 1.4301 Stainless steel screwed connection X5CrNi18-10 A2-70 Slate roof shape Weight 0.450 kg/pc W x H dimensions, material thickness 30 x 5 mm 3 x 7 mm hole for countersunk wood screws Pre-installed Incl. M8 x 25 hammer head screw set Can be adjusted in one axis	0020228536
	Universal cover plate, aluminium for shingle roofing, 246 x 205 mm (10 pcs)	0020228537
	"Biber Vario" roof hook, stainless steel for metal roof tile (10 pcs) Stainless steel A2; 1.4301 Stainless steel screwed connection X5CrNi18-10 A2-70 Beaver-tail roof shape Weight 0.592 kg/pc W x H dimensions, material thickness 30 x 6 mm 2 x 9 mm hole for countersunk wood screws Pre-installed Incl. M8 x 25 hammer head screw set Can be adjusted in one axis	0020228534
	"Biber Vario" metal roof tile, galvanised, DE For beaver-tail tiles, coverage 180 x 370 mm (10 pcs) Galvanised sheet steel Dimension 180 x 370 mm (coverage) Thickness 0.7 mm Weight 0.516 kg/pc Delivered with foam wedges for sticking	0020228535
	M 10 x 200 mm stair bolt without angle bracket (10 pcs) Material: A2 stainless steel Corrugated fibre cement roof shape, trapezoidal sheet metal, corrugated sheet metal Weight 0.123 kg/pc Pre-installed with three M10 locking nuts and one EPDM seal SW 7 drive **Note: Order the universal adapter for the aluminium rail (0020228540) separately**	0020228539
	Universal adapter for aluminium rail for stair bolt, Metal roof tile (10 pcs), angle bracket 60 mm, M10 complete Aluminium EN-AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Weight 0.087 kg/pc Foot hole for 10 mm screws Pre-installed Incl. M8 x 25 hammer head screw set Can be adjusted in one axis	0020228540

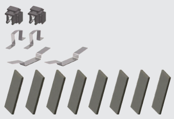
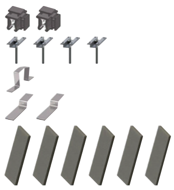
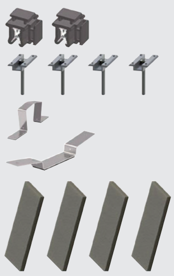
Accessories	Designation	Order no.
	Anti-slip guard, for pitched roof for PV module, upright installation (25 pcs) Stainless steel X5CrNi18-10 A2-70 M6 thread Screw length 20 mm Weight 0.008 kg/pc incl. M6 hex nut	0020228553
	Locking block, silver, pitched roof for PV module, transverse installation (20 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Weight 0.022 kg/pc Pre-installed	0020228554
	Locking block, black, pitched roof for PV module, transverse installation (20 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Weight 0.022 kg/pc Pre-installed	0020228541
	Wood screw, stainless steel, A2, TX 30, 6 x 80 Round-headed, for roof hook, standard (100 pcs) Stainless steel A2 Screw length 80 mm Weight 0.0153 kg/pc For aluminium roof hook With drill bit and anti-friction coating	0020228544
	Wood screw, stainless steel, A2, TX 40, 8 x 80/72 Round-headed, for roof hook, heavy load (100 pcs) Stainless steel X5CrNi18-10 Screw length 80 mm Weight 0.020 kg/pc For aluminium roof hook With countersunk head	0020228549
	Wood screw, stainless steel, A2, TX 25, 6 x 80 Countersunk head, for slate roof hook (100 pcs) Stainless steel A2 Screw length 80 mm Weight 0.0132 kg/pc For slate roof hook With drill bit and anti-friction coating	0020228550
	Fastening clip with cable tie to secure the DC cable (100 pcs) UV-resistant polyamide Dimension 200 x 3.6 mm Tensile strength 182 N Clamping area 0.7-3.0 mm Cable duct, variable parallel/90° to the clamping edge	0020228533
	Universal earthing terminal for connecting potential equalisation to the mounting rail (5 pcs)	0020271105

Accessories	Designation	Order no.
	Wood screw, stainless steel, A2, TX 30, 6 x 100 Round-headed, for roof hook, standard (100 pcs) Stainless steel A2 Screw length 100 mm Weight 0.0153 kg/pc For aluminium roof hook With drill bit and anti-friction coating	0020271098
	180 mm rail, silver For trapezoidal sheet roofs (10 pcs) Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 0.243 cm^4 Max. moment of resistance Wx = 0.157 cm^3 Dimensions (H x W x L) 14 x 31 x 180 mm Weight 0.088 kg/pc In each case, two holes 5 mm/6.5 mm/8.5 mm, pre-drilled Apply sealing tape extensively to the underside	0020271149
	395 mm rail, silver For trapezoidal sheet roofs (10 pcs) Aluminium EN-AW-6063 T6 Closed-cell cellular rubber, EPDM Max. torque of inertia Ix = 2.279 cm^4 Max. moment of resistance Wx = 1.358 cm^3 Dimensions (H x W x L) 25 x 80 x 395 mm 24 x 5 mm foot hole Weight 0.255 kg/pc 2 x 12 holes of 5 mm, variably pre-drilled Apply sealing tape extensively to the underside	0020271151
	Mounting triangle, 15°, silver For support (2 pcs) Aluminium EN-AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Dimensions, set up, 346.5 x 1145 x 1145 mm (a-b-c) Dimensions, transport 93 x 44.4 x 1145 mm Weight 1.926 kg/pc 2 x 12 holes of 5 mm, variably pre-drilled 15° orientation	0020271152
	Set mounting triangle, 25° orientation (2 pcs) For horizontal module arrangement Aluminium EN AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Dimensions, set up, 530.4 x 1145 x 1145 mm (a-b-c) Dimensions, transport 93 x 44.4 x 1145 mm Weight 2.074 kg/pc 25° orientation Can be used for auroPOWER VPV P	0010029480
	Set mounting triangle, 35° orientation (2 pcs) For horizontal module arrangement Aluminium EN AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Dimensions, set up, 698.9 x 1145 x 1145 mm (a-b-c) Dimensions, transport 93 x 44.4 x 1145 mm Weight 2.202 kg/pc 35° orientation Can be used for auroPOWER VPV P	0010029481
	Set mounting triangle, reinforcement set (1 pc) For stabilising the mounting triangle Aluminium EN AW-6063 T6 Stainless steel screwed connection X5CrNi18-10 A2-70 Dimensions 35 x 3 x 1900 mm Weight 0.536 kg/pc Can be used for auroPOWER VPV P	0010030584

Accessories	Designation	Order no.
	Bolt anchor For concrete (4 pcs)	0020271153
Fixing material/on-roof individual components (parallel with the roof), suitable for solar thermal energy and photovoltaics		
	Mounting rail, 47 x 35.4 mm, length 2606 mm, black (2 pcs) For installing 2 x solar flat plate collectors (vertical) or PV module When installing on on-site mounting supports or rafter anchors. Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 7.079 cm^4 Max. moment of resistance Wx = 3.155 cm^3 Dimensions (H x B x L) 47 x 35.4 x 2606 mm Weight 1.936 kg/pc Hammer head duct on the top of the rail	0020228571
	Mounting rail, 47 x 35.4 mm, length 1323 mm, black (2 pcs) For installing 1 x solar flat plate collectors (vertical) or PV module When installing on on-site mounting supports or rafter anchors. Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 7.079 cm^4 Max. moment of resistance Wx = 3.155 cm^3 Dimensions (H x B x L) 47 x 35.4 x 1323 mm Weight 1.983 kg/pc Hammer head duct on the top of the rail	0020228573
	Mounting rail, 47 x 35.4 mm, length 2123 mm, black (2 pcs) For installing 1 x solar flat plate collectors (horizontal) or PV module When installing on on-site mounting supports or rafter anchors. Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 7.079 cm^4 Max. moment of resistance Wx = 3.155 cm^3 Dimensions (H x W x L) 47 x 35.4 x 2123 mm Weight 1.578 kg/pc Hammer head duct on the top of the rail	0020228575
	End cap for mounting rail, 47 x 35.4, black (4 pcs) For sealing the mounting rail for installing on-site mounting supports or rafter anchors Aluminium EN-AW-6063 T6 Dimensions (H x W x L) 31 x 25 x 35.2 mm Weight 0.013 kg/pc	0020228578
	Rail connector for mounting rail, 47 x 35.4 mm (2 pcs) For connecting the mounting rails for installation on on-site mounting brackets or rafter anchors Aluminium EN-AW-6063 T6 Max. torque of inertia Ix = 7.007 cm^4 Max. moment of resistance Wx = 3.959 cm^3 Dimensions (H x W x L) 35.5 x 24.2 x 195 mm Weight 0.224 kg/pc incl. push-through protection	0020228576

Flat roof installation fixing material

Accessories	Designation	Order no.
Fixing material/flat roof, south, sets (elevated installation)		
	Basic set for first row, flat roof system, south, 10° for installing 1 x PV module 1 x fastening clip with cable tie to secure the DC cable 2 x top support, for flat roof system, south, 10° incline 2 x bottom support, for flat roof system, south, 10° incline 2 x M8 hexagon socket screw x 30 for flat roof system, wind deflector and ballast trough 2 x M8 washer x 30 A2 for hexagon socket screw, wind deflector and ballast trough 8 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020276006
	Basic set for additional row, flat roof system, south, 10° for installing 1 x PV module 1 x fastening clip with cable tie to secure the DC cable 2 x combination support, for flat roof system, south, 10° incline 2 x M8 hexagon socket screw x 30 for flat roof system, wind deflector and ballast trough 2 x M8 washer x 30 A2 for hexagon socket screw, wind deflector and ballast trough 4 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020273239
	Expansion set for first row, flat roof system, south, 10° for installing 1 x PV module 1 x fastening clip with cable tie to secure the DC cable 1 x clip for wind deflector for flat roof system 2 x module middle clip for flat roof system 1 x top support, for flat roof system, south, 10° incline 1 x bottom support, for flat roof system, south, 10° incline 1 x M8 hexagon socket screw x 30 for flat roof system, wind deflector and ballast trough 1 x M8 washer x 30 A2 for hexagon socket screw, wind deflector and ballast trough 4 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system	0020228559
	Expansion set as of second row, flat roof system, south, 10° for installing 1 x PV module 1 x fastening clip with cable tie to secure the DC cable 1 x clip for wind deflector for flat roof system 2 x module middle clip for flat roof system 1 x combination support, for flat roof system, south, 10° incline 1 x M8 hexagon socket screw x 30 for flat roof system, wind deflector and ballast trough 1 x M8 washer x 30 A2 for hexagon socket screw, wind deflector and ballast trough 2 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system	0020228560
	Alpin expansion set for flat roof system, south, 10° for installing 1 x PV module 1 x module end clip for flat roof system 1 x top Alpin support, for flat roof system, south, 10° incline 1 x bottom Alpin support, for flat roof system, south, 10° incline 1 x M8 hexagon socket screw x 30 for flat roof system, wind deflector and ballast trough 1 x M8 washer x 30 A2 for hexagon socket screw, wind deflector and ballast trough 1 x M8 galvanised steel well nut for flat roof system, bottom Alpin support **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020273240

Accessories	Designation	Order no.
Fixing material/flat roof, east/west sets (elevated installation)		
	Basic set for first row, flat roof system, east/west, 10° for installing 2 x PV module 2 x fastening clip with cable tie to secure the DC cable 2 x top support, for flat roof system, east/west, 10° incline 4 x bottom support, for flat roof system, east/west, 10° incline 12 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020276010
	Basic set for additional row, flat roof system, east/west, 10° for installing 2 x PV module 2 x fastening clip with cable tie to secure the DC cable 2 x top support, for flat roof system, east/west, 10° incline 2 x bottom support, for flat roof system, east/west, 10° incline 8 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020273245
	Expansion set for first row, flat roof system, east/west, 10° for installing 2 x PV module 2 x fastening clip with cable tie to secure the DC cable 4 x module middle clip for flat roof system 1 x top support, for flat roof system, east/west, 10° incline 2 x bottom support, for flat roof system, east/west, 10° incline 6 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020273242
	Expansion set as of second row, flat roof system, east/west, 10° for installing 2 x PV module 2 x fastening clip with cable tie to secure the DC cable 4 x module middle clip for flat roof system 1 x top support, for flat roof system, east/west, 10° incline 1 x bottom support, for flat roof system, east/west, 10° incline 4 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.	0020273243
	Alpin expansion set for flat roof system, east/west, for installing 2 x PV module 1 x top support, for flat roof system, east/west, 10° 2 x bottom Alpin support, for flat roof system, east/west, 10° **Note: Order the edge clamps for flat roof installation separately depending on the thickness of the module frame.**	0020273244
Fixing material/flat roof, south and east/west sets (elevated installation)		
	Ballast trough expansion set for flat roof system, south and east/west 10° 1 x ballast trough for flat roof system 4 x M8 carriage bolt x 20 A2 for flat roof system, ballast trough 4 x M8 hexagon socket nut x 16 A2 for flat roof system, ballast trough 4 x M8 washer x 30 A2 for hexagon socket screw, wind deflector and ballast trough 1 x M8 galvanised steel well nut for flat roof system, bottom Alpin support and ballast trough 2 x structural protection mat with felt, 200 x 80 x 10 mm for flat roof system	0020228530
	Flat roof end clamp, 50 mm, silver, flat roof system 10° south and east/west (4 pcs) **Note: Observe the frame thickness for the module.** Required in combination with the flat roof system set: 1 x basic set, south, 1st and other rows 2 x basic set, east/west, 1st and other rows 1 x expansion set, east/west, 1st and other rows 1 x Alpin expansion set, east/west Alpin expansion set, south = 0.25 x	0020273253

Accessories	Designation	Order no.
	Flat roof end clamp, 35 mm, silver, flat roof system 10° south and east/west (4 pcs) Required in combination with the basic set 1 x for 1st and 2nd row, flat roof system, south 10° for installing 1 x PV module and basic set 2 x for 1st and 2nd row, flat roof system east/west 10° for installing 2 x PV module and 1 x for expansion set for 1st and 2nd row, flat roof system, east/west 10° for installing 2 x PV module. Required as 0.25x in combination with Alpin expansion set for flat roof systems, south 10° for installing 1 x PV module. Required as 1x in combination with Alpin expansion set for flat roof systems, east/west for installing 2 x PV module.	0020273254
	Flat roof end clamp, 42 mm, silver, flat roof system 10° south and east/west (4 pcs) Required in combination with the basic set 1 x for 1st and 2nd row, flat roof system, south 10° for installing 1 x PV module and basic set 2 x for 1st and 2nd row, flat roof system east/west 10° for installing 2 x PV module and 1 x for expansion set for 1st and 2nd row, flat roof system, east/west 10° for installing 2 x PV module. Required as 0.25x in combination with Alpin expansion set for flat roof systems, south 10° for installing 1 x PV module. Required as 1x in combination with Alpin expansion set for flat roof systems, east/west for installing 2 x PV module.	0020273255

Accessories for the eloPACK battery bank system

Designation	Order no.
eloPACK storage expansion, 1.975 kWh, expansion to the LiFePO4 battery module to increase the usable capacity up to maximum 11.850 kWh	0020228461
Additional three-phase external power measurement, 0-60 A per phase The charge behaviour of the battery bank system can therefore be precisely tailored to the actual energy that is produced. Without this accessory, only one inverter and/or one roof alignment via extrapolation can be recorded. The external power measurement can also be used to record the power generated by a modulating CHP system. A dynamic reduction in power at the feed-in point cannot currently be applied at this part of the generating installation. (The space requirement for the sub-distribution to analysers that are to be installed is seven machine spaces.) **Note: Not required when combined with ecoPOWER 1.0 non-modulating generating installations.**	0020228465
Set of radio-controlled outlets, 3 pcs The radio-controlled outlets, which are available as an option, allow you to automatically, intelligently switch on electrical appliances in the house. The radio-controlled outlets can also be manually activated/deactivated (via the Internet portal, the app or directly on the radio-controlled outlet). The LED ring is used to visualise the current power that is currently being used by the radio-controlled outlet.	0020228467
Measuring range extension up to 100 A With the measuring range extension, currents of up to 100 A can be measured. The scope of delivery contains two external current transformers for the measurement range 0-100 A. These replace the standard current transformers 0-60 A that were supplied.	0020228468

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