AERS

ADVANCED ENERGY STORAGE

HES6/10 Installation Guide

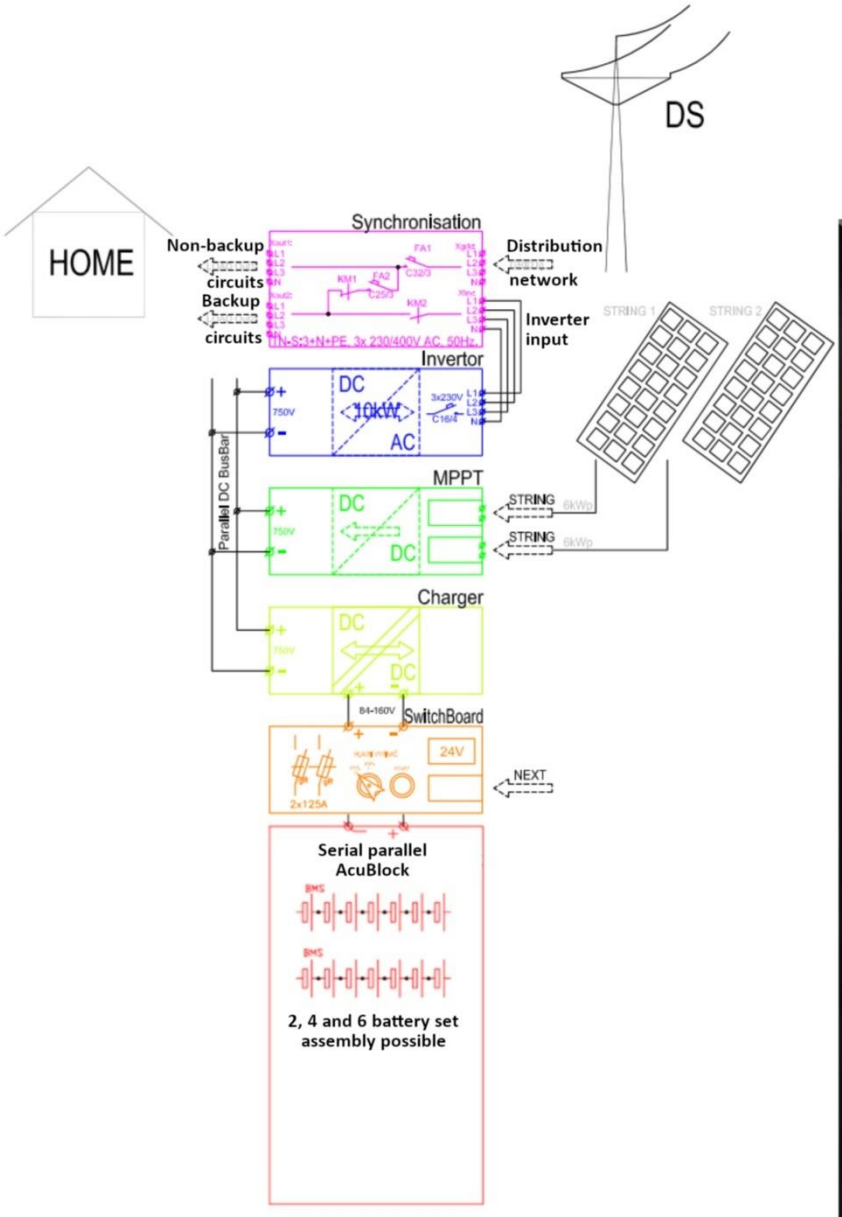
Connecting a storage station to the grid and photovoltaic panels

Contents:

1. Introduction – Equipment description

The Energy Storage Station (HES6/10) consists of a modular system of electronic power and storage units, designed to the technical standard of a 19" rack. The concept allows to build configurations of the storage station according to the needs of the target application. The basic types of assemblies have been defined for the market and are described in this technical description. The basic concept of the HES storage station assembly is shown in the figure.

The HES station assembly can be custom modified; the custom modification must be addressed in the preparatory phase of the project implementation (order-delivery).



1.1. Brief technical description

The HES station consists of the following functional blocks:

RACK – The steel and sheet metal rack is designed with a footprint of 600x600 mm. It is designed to accommodate individual units that form separate functional units. The main parts of the DC and AC power buses are integrated in the rack. The racks can be manufactured in different size variants to suit the specific customer installation of the selected units within the configuration. HES configuration is described in section 1.3.

Synchronization – the unit provides parallel connection to the distribution network and continuous measurement of their parameters. The unit measures the voltage and current at the input of the connected building. It ensures safe and functional disconnection of the equipment from the network and protection of all outputs. The size of the unit is 3U.

Inverter – power 3-phase inverter unit. It operates in 4Q mode. It enables charging of batteries from the distribution network, but also covers the current consumption in the building. It is designed as a 4-branch inverter without isolation transformer with unbalanced phase load control. The station allows multiple inverters to run in parallel. The size of the unit is 4U.

MPPT – the unit ensures the collection of energy from individual solar strings. The unit is equipped with two DC/DC converters that supply power to a common DC bus. All power units are connected to this one. The station allows multiple MPPT harvesters to run in parallel. The size of the unit is 4U.

Charger – the charger unit controls the charging of the batteries. It collects data on each cell and evaluates the contribution to the connected load based on their condition. It galvanically separates the batteries from the rest of the system. All energy flow management is implemented in the unit. It provides an interface with smart home and remote monitoring. The entire HES station can be controlled via this unit. The size of the unit is 4U.

SwitchBoard – the module is controlled by the Charger unit. It includes DC power contactors for connecting batteries to the Charger. The unit has a protection of the connected batteries and a main 24V system voltage source, which is powered from the batteries. On the unit there is the main switch of the HES station and the START button. The size of the unit is 3U.

ACU-PACK – the unit contains 2 to 6 batteries with an installed capacity of 13.7 to 41.1 kWh. The unit is equipped with a BMS system that evaluates the status of individual cells, distributing to the parent system via CAN communication. ACU-PACK allows balancing of all cells connected to it.

1.2. Basic technical parameters of HES6/10 in the HES version

Operating voltage system (input/output), U_n	TN-S, 3 x 230/400 V AC, 50 Hz
Operating current of the 3f_inverter output connection	16 A
Power factor cos(phi)	1–0.95
Operating voltage range	0.8 Un–1.1 Un
Rated input frequency (operating range)	50 Hz, (47.5 Hz–51.5 Hz)
Internal supply voltage	24 VDC
External temperature range	0 °C to +40 °C
Altitude	up to 2000 m
Humidity	85% non-condensing
Cover	IP40 with doors closed
noise level	medium: approx. 30dB, 50dB in operation
Rack:	
Design:	steel and sheet metal rack
Rack size type	600 x 600 x 1912 mm
Total weight kg	Type 1: 265 kg, type 2: 330 kg, type 3: 395
HES6/10 inverter output:	
Nominal voltage U_n	3 x 230/400 V, 50 Hz, TN-S
Output power P_n	10 kW
Maximum output power P_{max}	13.8 kW (5 min)
Nominal output current In	14.5 A / max. 20 A
Solar inputs:	
Operating voltage range per PV input: U_{PV}	300–600 V DC
Maximum voltage at idle:	700 V DC
Number of PV inputs in one MPPT module:	2
Max. current per 1 PV input:	20 A
Max. power per 1 PV input:	6 kW
MPPT adaptation efficiency:	99.0% scan period 5 min.
MEB battery pack capacity:	6850 Wh
Battery type:	MEB, LG Chem – maintenance-free
Module design (AcuPack)	3p8s, BMS01(AERS) assembly
EURO efficiency:	
PV -> AC:	96%
BAT -> AC:	93.5%
Design type 1:	
Number of MEB modules:	2
Installed capacity:	13.7 kWh
available continuous power from Acu (1 hour)	7.7 kW
Total DC voltage of Acu set	approx. 48–68 V
Current load Acu set at permanent available power	approx. 120–160 A
Time of Acu power availability:	approx. 1 hour
Design type 2:	
Number of MEB modules:	4
Installed capacity:	27.4 kWh
available continuous power from Acu	10 kW
Total DC voltage of Acu set	approx. 48–68 V
Current load Acu set at permanent available power	approx. 60–80 A
Time of Acu power availability:	approx. 2 hours
Design type 3	
Number of MEB modules:	2
Installed capacity:	41.1 kWh
available continuous power from Acu	10 kW
Total DC voltage of Acu set	approx. 48–68 V
Current load Acu set at permanent available power	approx. 40–54 A
Time of Acu power availability:	approx. 3 hours

Expanding higher capacities:

Expansion of the capacity of individual assemblies can be done in individual pairs of AcuPacks (sets), i.e. 13.7 kWh each. The expansion battery must be housed in an external dedicated rack.

Protection against dangerous contact
The protection against dangerous contact is performed by a cover in accordance with ČSN 33 2000-4-41 ed. 2.

Protection against dangerous contact with non-live parts
Protection will be performed by the user according to ČSN 33 2000-4-41 ed. 2. and ČSN 33 2000-5-54 ed. 3., by automatic disconnection from the power supply, with current protectors Ia = 30 mA. PROTECTION SHALL BE CONDUCTED ON THE OUTPUT TERMINALS BEHIND THE OUTPUT TERMINALS OF THE EQUIPMENT (marked as LOAD) AS PART OF THE OPERATOR'S MAINS. In addition, increased protection must be implemented at the user/operator by means of interconnection.

Environmental influences
The equipment is classified according to ČSN EN 62109-1 as PD2.

For the HES6/10 equipment, the determination of the operating environment was carried out according to ČSN 33 2000-5-51 ed. 3 and ČSN 33 2000-1 ed. 2:

Indoor spaces: residential and non-residential spaces; normal, mostly free from special influences

AA4 – temperature 0 to 40 °C
AB4 – humidity 5 to 85%, rooms protected from atm. influences without temperature control
AB5 – rooms protected from atm. influences with temperature control (indoor heated rooms)
AD1 – negligible effect of water
AE1 – foreign bodies, dust – low
AC1 – altitude – up to 2000m, (AC2 altitude above 2000m with limited power)

AF1 – corrosion – negligible
AH1 – vibration – negligible
BA1 – human capability – basic (layman)
BC1 – ground contact
BD1 – leakage – slight
Ad4 – external inputs

Due to the nature of the use of the equipment, overvoltage category No. IV has been determined for the AE6/10 station.

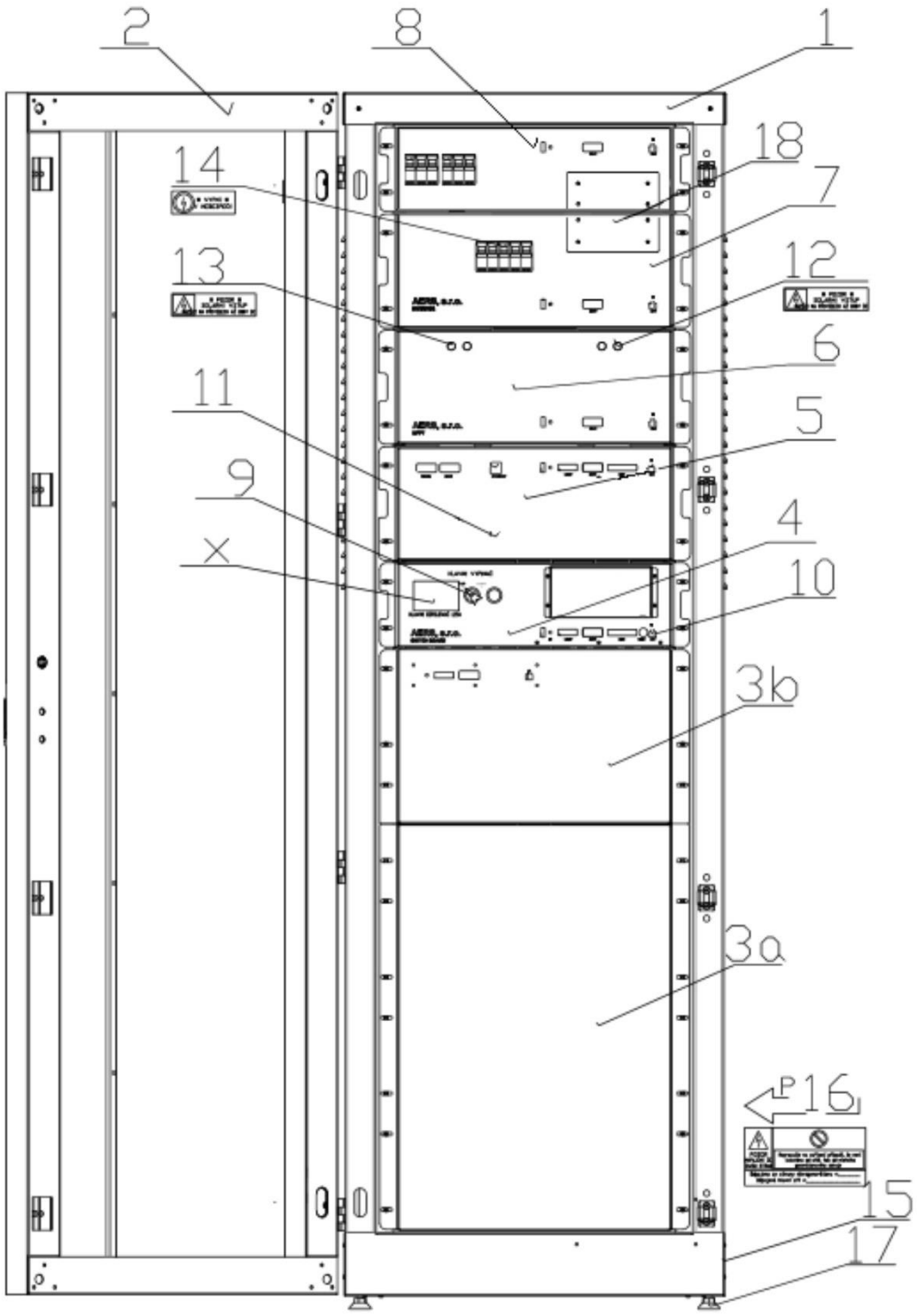
1.2.1. Handling and installation of the equipment

The equipment is intended for static placement. It is not allowed to handle the equipment in the set-up state with the units fitted. Handling and positioning must be done at the installation site by equipping the rack with the individual units gradually. Each installed unit must be properly bolted to the rack with specified bolts. The individual bolts ensure the mechanical rigidity of the equipment and the safety function of the protective connection against electric shock.

The equipment is not equipped with hanging points. Handling of the unassembled unit rack must be carried out without excessive impact, with the option of a transport position on the back or on the side. Use a pallet truck for handling. Other loading and handling is not permitted and may result in damage to the load-bearing and safety features of the equipment.

1.3. Contents of delivery – description of the HES6/10 station

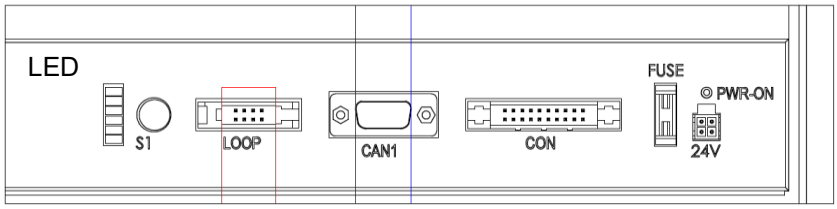
The HES6/10 in the HES version is supplied as a complete unit of equipment. During installation (mounting) it is equipped with all units and power and communication cables, see the description.



AES6/10 delivery assembly of the HES version		
position	*marking*	*description*
System units:		
1	Rack:	Steel and sheet metal load-bearing structure
2	Door	Steel and sheet metal in open position
3a	Battery cover	Battery compartment cover plate
3b	BMS cover	Cover plate for BMS compartment and battery fuses
4	Switchboard	24V battery and power supply connection unit
5	Charger	Power battery charger unit, HES master unit
6	MPPT	DC/DC solar inverter unit
7	3f_Inverter	3f/4Q power inverter unit
Description of other HES6/10 equipment		
8	Synchronisation	Parallel running unit with network
9	MAIN SWITCH	Two-position rotary main station switch + Start button
10	24V power supply	24V power supply output for powering units
11	ETHERNET + CAN2	Connectors for internet connection and SYN02 measuring unit
12	PV String 2	Solar input from String 2
13	PV String 1	Solar input from String 1
14	4p main AC circuit breaker	Power inverter output circuit breaker, 4p version with voltage trigger
15	Production label	Position of production label placement
16	X_sys	Main power connection terminal block AC and PV_DC position
17	feet	The station is equipped with adjustable feet to ensure stability
18	terminal covers	Sheet metal covers for power inverter output terminals and synchronization

1.3.1. HES6/10 unit connector interface description

Each unit is equipped with a connector interface. The positions and names of the connectors are shown in the following figure.



Description of the basic connector interface of HES6/10 units	
marking	description
S1	Control button
LOOP	Connector for controlling the battery part, safety signal loop
CAN1	Connector for connecting the system bus, which ensures the operation and control of individual units.
CON	Functionally equipped connector for handling inputs and outputs. Primarily used to control the operation between CHARGER and Switchboard units (not used on some units).
FUSE	Position for 24V fuse placement (not used on some units)
24V	24V system (on-board) power supply connector
PWR-ON	LED indication of 24V power supply connection (not used on AcuPack units)
LED	Position of status LED signalling.
ETHERNET	LAN data cable connection connector
CAN2	AcuPack system bus connector
RS485	Connector for communication with an external device

Meaning of LED status indication for individual units:

LED position	AcuPack	SwitchBoard	Charger	MPPT	3f_Inverter	Synchronisation
LED1 (green)	Sig.ext.24V	- x -	Auto mode	READY	READY	READY
LED2 (RED)	- x -	- x -	FAILURE Perma Err.	FAILURE	FAILURE	FAILURE /flashing wrong phase sequence
LED3 (green)	- x -	KM1 switch	ISLAND	RUN	RUN	RUN
LED4 (green)	- x -	KM2 switch: BAT	- x -	- x -	ISLAND	KM2 switch/flashing wrong phase sequence
LED5 (green)	- x -	Sep. pre-charging	- x -	- x -	AFE	KM1 switch/flashing wrong phase sequence
LED6 (green)	- x -	Sep. CHA input discharge	- x -	- x -	- x -	- x -

Within the internal CAN system communication it is necessary to ensure impedance termination of both ends of the bus. For this purpose, the control processor units are equipped with mounting contacts (jumpers). Fitting

of termination jumpers is performed at the factory during final tests. In case of faults detected by the CAN bus, it is necessary to check the status of the termination jumpers. → STATED IN THE UNIT TEST REPORT.

Internal system supply voltage 24V:
The HES6/10 station has a common 24V power supply for all units in the system. The power source is the battery part of the station, which supplies the 24V / 150W system voltage. Turning off the MAIN SWITCH and pressing the START button will connect the power supply to the batteries. The station must therefore be connected to either a solar power source or an AC supply for long-term operation, from which the batteries are partially charged in the event of their discharge to avoid shortening their lifetime. If the station is disconnected from any power source for a long period of time and the cells are discharged, the station will disconnect the power supply from the batteries and shut down safely.

2. Installation

2.1. Legend of safety warnings:

DANGER! A symbol indicating an imminent situation that may cause death or very serious injury to the person handling the equipment.

RISK! A symbol indicating the possibility of hazardous situations that could cause death or very serious injury to the person handling the equipment.

CAUTION! A symbol indicating the possibility of situations that may cause minor injuries or minor injuries and material damage.

ATTENTION! A symbol indicating a possible threat to the quality of the results or damage to the equipment.

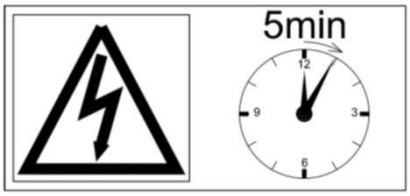
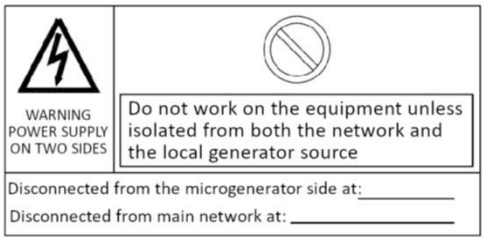
WARNING! Risk of electric shock.

WARNING! Risk of burns, hot surface. This notice relates to the internal parts of the units and therefore applies only to authorised persons carrying out service work.

Equipment components can be recycled.

The equipment must not be disposed of as normal municipal waste.

Warning labels placed on the equipment:

Warning labels and their placement on HES6/10		
Label	*Position*	*Description / placement*
	8, 10, 11	In the event of a fault on the equipment or on the wiring, switch off the equipment. For tripping and safety devices that are accessible to the operator when the door is opened.
	24, 25	Placement on the cover panels of the connection between the 3f_inverter unit and Synchronisation. It is forbidden to remove or tamper with these cover panels.
	13, (14, 15), 22, Uh2, Ubat	Warning of the possibility of electric shock if the 5 minute delay after switching off and disconnecting is not observed, after which installation work can be carried out safely. Placed at all connection terminals, connectors and internal buses.
	(14, 15), 22	Warning for connecting an external solar power source. Located at the individual terminals of the solar inlets and connectors.
	22	Table alerting to power supply on two sides. Placed on the outer side cover where the connection terminal block is installed inside. THE LABEL SHOULD ALSO BE PLACED ON THE MAIN HOUSE SWITCHBOARD AND ON THE RH SWITCHBOARD TO WHICH THE AES/HES OUTPUT IS CONNECTED.
	DOOR	Warning against extinguishing with water or foam extinguishers. Placed on the front door of the station on the outside at a height of 150–120 cm.
	1a, 1b, 1c, 1d	Accumulated energy. Placement on AcuPack front panels

If any of the above symbols appear anywhere on the equipment or in the installation instructions or operating instructions, it is essential to pay attention to them!

2.2. Safety instructions

To avoid personal injury and material damage, the installation and maintenance/service instructions must be followed without fail, otherwise risks cannot be avoided.

For the above reason, only a properly trained person is authorized to install/put the hybrid system in operation, observing all technical regulations and instructions given in the installation manual and the operating instructions.

All wiring and surge protection installation on the equipment shall be performed only by a properly trained electrician with a valid license and training per the Decree, Section 50 and in compliance with all safety regulations. Ensure that the AC and DC sides of the inverter are disconnected prior to any connection work.

A “CAUTION POWER ON TWO SIDES” warning label must be placed on the main house switchboard and on the RH switchboard to which the AES/HES equipment is connected with a backup output.

2.3. Fire prevention

Improper or unprofessional installation may result in a risk of damage to the storage station and other conductive components of the photovoltaic system.

Failure to comply with the technical and safety conditions of the installation instructions can lead to overheating of the equipment or cables and to insulation damage and arcing at the cable terminal points. Thermal damage can lead to a fire in the equipment.

The following instructions must be observed when connecting the AC and DC cables:

- It is necessary to tighten all connection terminals with the correct tightening torque according to the size and type of the screw connection. The tightening values for the individual sizes of screw connections are given in Table 1.

- All earth terminals (PEN/PE/GND) must be properly tightened to the tightening torque according to the size and type of screw connection, see Table 1, and a locknut should be used if appropriate to ensure safety. Also check for loose ground terminals.

- Care must be taken to avoid overloading the cables. Inspect the cables for damage or improper routing before installation/maintenance/service.

- Always follow the safety instructions in the installation and maintenance manuals when installing/maintaining/servicing and observe local connection regulations

Only put the inverter into operation if you have tightened the fixing screws firmly to the correct tightening torque.

BEFORE CONNECTING THE INDIVIDUAL PARTS OF THE SOLAR SOURCE AND ITS SUPPLY TO THE HES6/10 DEVICE, IT IS NECESSARY TO CARRY OUT A THOROUGH QUALITY CHECK OF THE DESIGN AND TO MEASURE THE INSULATION CONDITION OF THE ENTIRE SOLAR SYSTEM, INCLUDING ALL PARTS OF THE SUPPLY LINES. ALL SUPPLY WIRES MUST BE OF A SUITABLE TYPE AND THE SAME CROSS-SECTION AND MUST BE TERMINATED AND SECURED AGAINST DISCONNECTION AT THE APPROPRIATE TERMINALS. **THE SOLAR FIELD/ARRAY SUPPLIER IS RESPONSIBLE FOR THE DESIGN AND SAFETY OF THE SOLAR PART.**

AERS s.r.o. shall not be liable for any costs associated with generation outages, installation costs, etc. that may arise due to a detected electrical arc resulting from improper installation of the solar field/array, or improper installation of HES6/10, or the consequences of improper operation. If an arc

is detected during the installation or handling of the solar cables, the entire photovoltaic system must be checked for faults or damage to the insulation of the installation before restarting the inverter.
To avoid personal injury and material damage, the installation and maintenance/service instructions must be followed without fail, otherwise risks cannot be avoided.

2.4. Regulatory use

The HES6/106 storage station combines the functions of solar energy recovery in DC electric form, its storage and conversion to AC for further use. The equipment is composed of MPPT inverters which supply energy from solar inputs to the internal intermediate circuit. The energy from it is stored in accumulators or supplied to appliances or the distribution network by a 3f_inverter. The HES6/10 station also ensures the supply of electricity for the building's consumption in the event of a fault or failure of the distribution network in the ISLAND mode. The output of the inverter allows the supply of current of different magnitudes to the individual phases and also allows complete mutual reversal of the currents on the individual phases. Measurement and switching of individual power modes is performed by the Synchronization unit, which has a built-in smart meter function. It allows direct control of the power supplied or drawn by the 3f_inverter on individual phases and thus balancing the asymmetrical consumption currents of the building.
The following shall be deemed to be uses contrary to regulations:

- Any use not specified in the preceding paragraph and uses beyond the functional scope of the equipment.
- Any modification to the HES6/10 station equipment that has not been specifically recommended by AERS s.r.o., or any tampering with individual assemblies that does not comply with the installation manual or maintenance/service manual
- Use of components that have not been specifically recommended or used by the manufacturer (AERS s.r.o.) for the installation of the equipment
- Any manipulation of the batteries that contradicts the installation manual or maintenance/service manual
- Any manipulation of the meter that contradicts the installation manual or maintenance/service manual

If it is found that the equipment has been used in any of the above mentioned ways that are contrary to the regulations, the warranty of the equipment automatically expires and the company (AERS s.r.o.) shall not be liable for any damages caused by such use.

The following shall also be considered part of the regulatory use of the equipment:

- Careful reading and following of the instructions in the installation and maintenance/service manual
- Ensuring regular maintenance and inspection/revision checks.

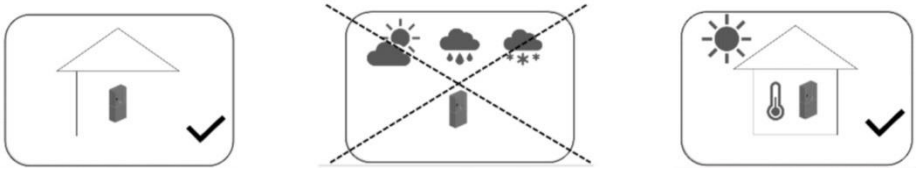
It must be ensured that all components of the photovoltaic system are operated only within the permitted operating range (power, voltage,...).

Observe all measures recommended by the solar panel manufacturer to maintain the performance of the solar panels.

Comply with all plant regulations for supplying power to the grid, operating with an emergency power source, and operating storage systems.

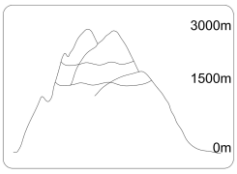
2.5. Choosing the location of the storage station

HES6/10 is designed for indoor operation only.



Do not expose the equipment to direct sunlight to reduce the possibility of it heating up. Install the equipment in a protected location, e.g. in a utility room, garage or basement of the building. Ensure that the room is sufficiently ventilated and that the permissible relative humidity is not exceeded.

Solar PV input power: U_{DCmax} in altitude:

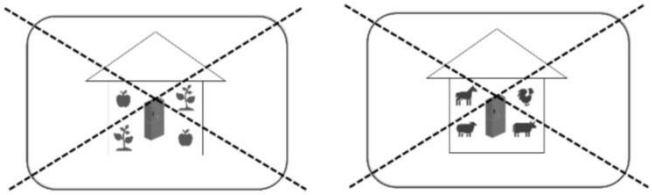


- 0 to 2000 m = 700 V / 6 kW
- 2000 to 2500 m = 600 V / 5 kW
- 2500 to 3000 m = 600 V / 4.5 kW

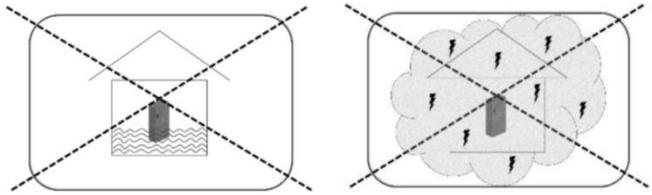
It is not permitted to install or operate the equipment at altitudes above 3000 m.

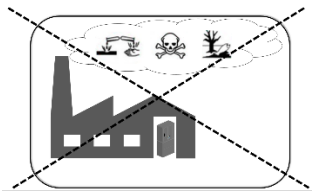
Do not install HES6/10 in the following locations:

Greenhouses: Agricultural storage and compound feed preparation areas, stables

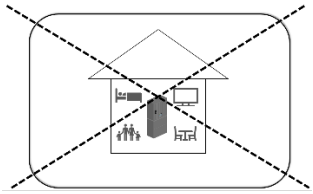


Areas at risk of flooding Avoid areas with high dust exposure and areas with high conductive particle dust exposure (e.g. iron filings)



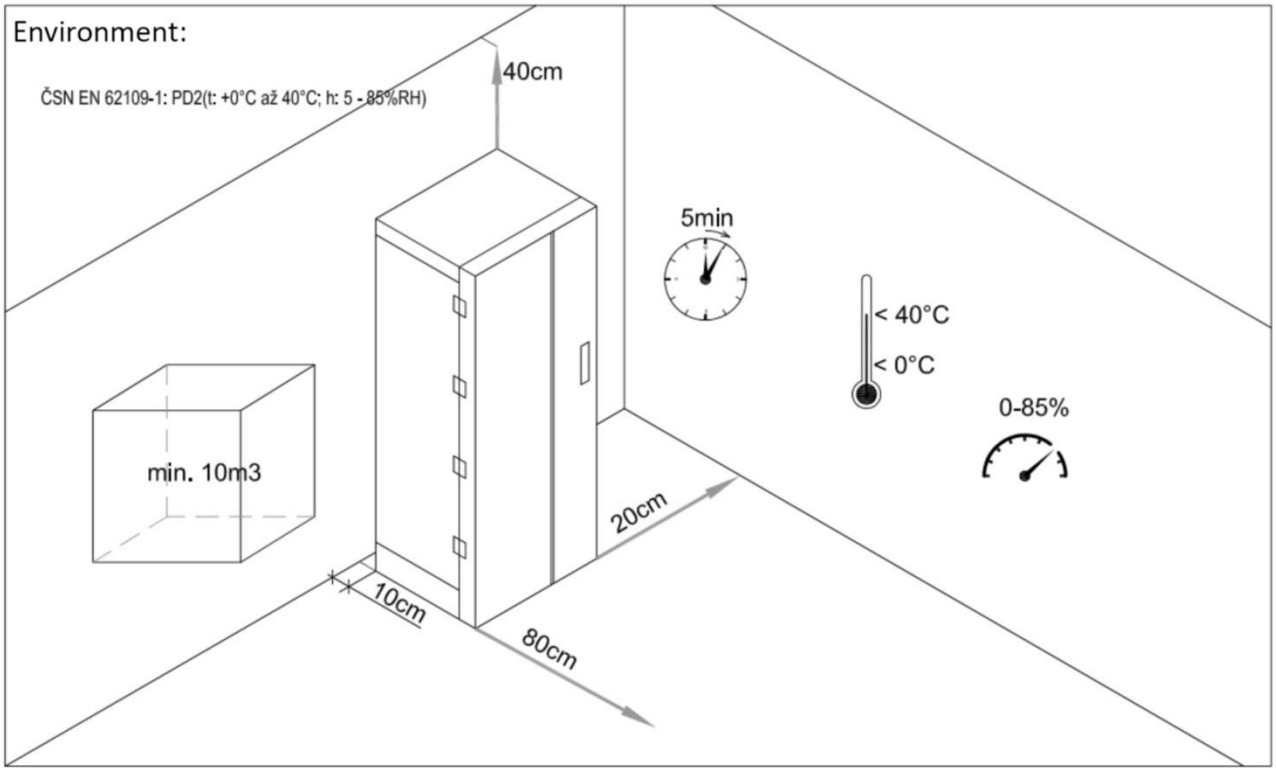


The installation site must not be contaminated with ammonia, corrosive vapours, salts or acids.



Due to the slight noise generated during operation of the equipment, we do not recommend installation in close proximity to bedrooms and living areas.

For the installation of the station, observe the following spacing and environmental parameters:



Only install the equipment on a solid surface!

The equipment must be operated in a location that provides sufficient distance from surrounding objects.

Install the equipment in areas where the temperature does not fall below 0 °C and does not rise above 40 °C.

Install the equipment in rooms with relative humidity not exceeding 85% without condensation.

The equipment is made with IP20 protection.

The equipment must be installed so as to provide access to the connection terminals and to provide access to the means of disconnection from the side of the equipment rack.

If you are installing the equipment in an enclosed space, distribution box or a similar enclosure, ensure sufficient heat extraction by means of forced ventilation.

The direction of air flow inside the storage station is backwards and upwards (cold air inlet from the sides, warm air outlet from the back).

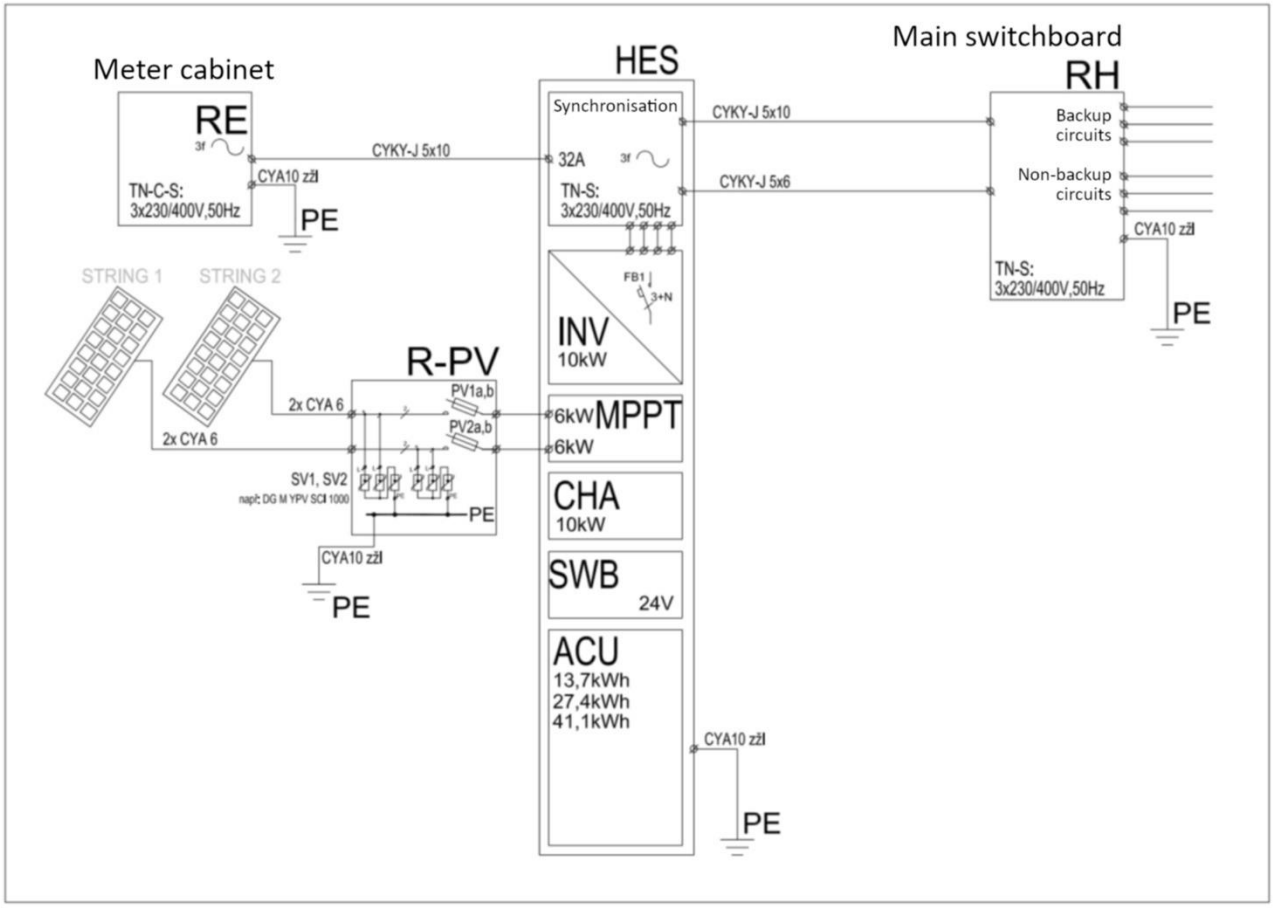
2.6. Power connection of the HES6/10 station to the distribution network and solar inputs

The HES6/10 station has a connection interface to the network and to the appliances in the TN-S: 3x230V/400V,50Hz, i.e. 5-conductor.

In addition to the DNO, the installer or user must inform the electricity supplier and/or metering organisation.

Installation instructions:

Metering point, i.e., the billing metering point is not part of the HES6/10 station and the manufacturer assumes the location of the metering device in the meter cabinet at the supply from the DN, see the figure below.

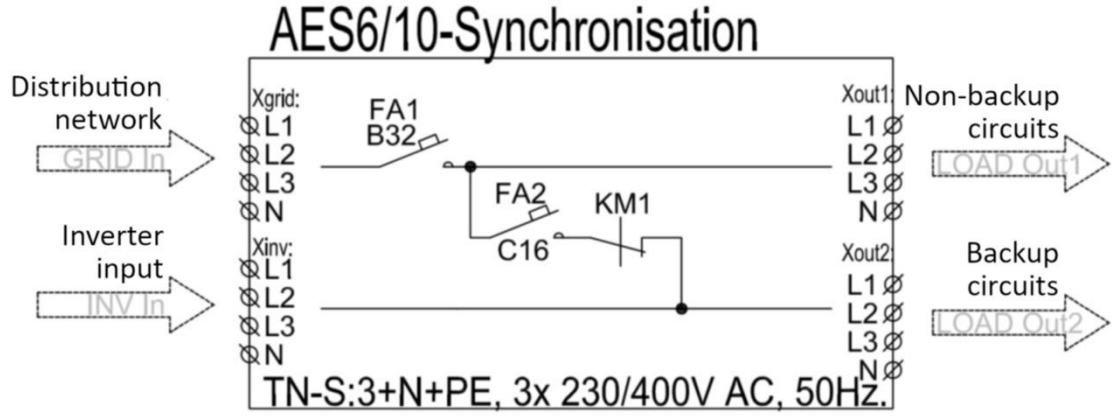


The HES6/10 station provides measurement of the power drawn from the RE supply for the entire consumption of the connected part or the whole building. The supply of power from the solar panels is made against the total consumption of the building and allows suppression of the current drawn from the DN for all appliances. In the event of a failure of supply from the DN , i.e. when switching to the ISLAND mode, the station supplies power to the so-called. BACKUP CIRCUITS. NON-BACKUP CIRCUITS are still connected to the grid, but the power inverter of the HES6/10 station does not supply current to the circuits. Connection and disconnection of individual circuits is performed by the Synchronisation unit.

The Synchronisation unit provides all measurements of instantaneous values of the power drawn from/supplied to the distribution network and the function of parallel connection of the 3f_inverter output to the AC supply network to the building. The inverter output is designed for circuits selected for backup in the ISLAND mode.

The supply from the DN, which is routed through the Synchronisation unit, ensures the measurement of all connected draws in the backed-up and unbacked-up output branch. The supply and compensation of the power drawn from the grid using the solar source and batteries is thus ensured for all connected appliances during normal operation.

The power inverter has output terminals equipped with a 16A circuit breaker with C characteristic. For backup circuits, it is therefore necessary to take into account the specified value of output current for the transition to island mode in the event of a network failure. The power supply of the solar inverters towards the inlet, i.e. to the Distribution Network (DN), and which is possibly subject to contracted energy off-take from the grid generation plant is functionally maintained. The block diagram of the Synchronisation unit is shown in the figure below.



Block diagram of the HES6/10 Synchronization unit for the purpose of documentation of the description of the HES6/10 station connection to the DN in parallel operation with the network.

More connection information for distributor's needs:

Breakdown point:

The HES6/10 station is equipped with a Synchronization unit for the purpose of creating a Breakdown Point. It is wired to ensure a controlled parallel connection of the output inverter to the DN and to ensure disconnection of the operator's distribution (backup circuit) from the DN in the event of an outage or failure of the DN. The block diagram of the HES6/10 Synchronization unit is shown in the figure below.

Description of the electrical or mechanical interlocking:
The connection (switching) element that connects the HES6/10 station as a solar power plant to the DN is the KM2 contactor located in the Synchronization unit. The contactor is used to connect the output of the power inverter (INV) in parallel to the DN supply. The KM1 contactor is used to disconnect the DN when switching to the "ISLAND" mode, according to EN 50438ed2. The wiring of the HES6/10 station to the applicant's installation is shown in Figure 2.
A complete shutdown of the solar power plant HES6/10 from the DN is done by switching off the main switch of the station and switching off the 4-pole output circuit breaker FB1 (output of the power inverter INV). The connection of the operator's internal wiring is performed automatically in the off state by the KM1 expansion contactor, which is part of the Synchronisation unit.

Phasing point:
To ensure phasing and connection to the DN, the HES6/10 station is equipped with its own measuring electronics in the Synchronisation unit, which ensures instantaneous measurement of all operating variables in the network. This ensures the correct phase connection of the outputs of the HES6/10 power inverter. The Synchronisation unit is part of the HES6/10 station unit.

Interruption of supply from DN – description of station operation:

The HES6/10 station is equipped with means of quality fault detection and interruption of power supply from the distribution network (DN) to ensure the function of bridging outages in the system. Measurement and detection is performed in the Synchronisation unit and in the HES6/10-3f_Inverter power inverter unit. This arrangement guarantees an immediate response to the immediate occurrence of a fault in the DN. When a mains fault is detected in the mains supply mode, the inverter automatically switches to limited island mode and the Synchronisation unit disconnects from the DN by opening the KM1 contactor. The transition to the intentional island mode takes place immediately after the disconnection of the KM1 contactor according to EN 62116ed2.

Restoration of supply from DN – description of station operation:

When the electricity supply from the distribution network is restored, a phase comparison is first made against the restored DN. The connection is performed by switching the KM1 contactor and simultaneous controlled switching off of the power inverter HES6/10-3f_Invertor. A new start-up of the power supply to the DN is implemented subsequently according to ČSN EN 50438ed2 after 60 seconds of network stability monitoring.

Safety when connecting the station

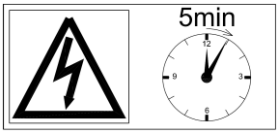
Before starting the installation and commissioning of the equipment, the installation and operating instructions for the equipment should be read carefully. Only trained operators are authorised to install the equipment, provided that they fully comply with the technical requirements set out in the installation instructions. Untrained operators and improper installation can cause damage to the equipment or to the health of the operator.

In case of unprofessional handling or handling beyond the safe connection of the equipment, i.e., opening of individual power modules, there is a risk of electric shock that can cause injury or death. There is also a risk of shock from the mains voltage and the uniform voltage from the solar panels or battery when handling the equipment.

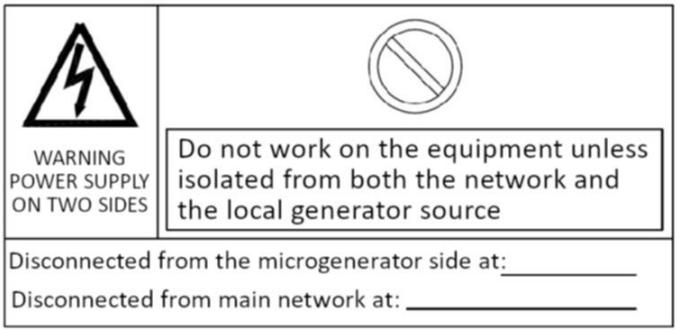
- IT IS FORBIDDEN TO OPEN THE INDIVIDUAL POWER MODULES AND MAKE ANY INTERVENTIONS IN THE INTERNAL WIRING.

- EACH CARTRIDGE MODULE IN THE HES6/10 EQUIPMENT IS A SEPARATE MINIMUM REPLACEABLE PART FROM A SERVICE AND INSTALLATION POINT OF VIEW AND MUST THEREFORE BE HANDED OVER TO THE MANUFACTURER OR AN AUTHORISED SERVICE CENTRE FOR REPAIR IN THE EVENT OF A FAILURE..

To ensure safety, all AC and DC power leads must be disconnected from the supply side by approved circuit breakers and disconnecting devices before any manipulation of the equipment. For safety reasons, further manipulation of the equipment can only be carried out after **5 minutes** have elapsed, during which time the internal circuits of the equipment are safely discharged.



!WARNING! The HES6/10 station is an equipment powered from two sides, therefore before any manipulation it must be ensured that the individual inputs and outputs of the equipment are disconnected and the equipment is switched off by the main switch. The equipment also includes circuit breakers which must be switched off (downwards) before manipulation.



The HES6/10 station is equipped for mounting connection terminals on both the right and left side. Access to the terminal block is covered by a side plate. The position on which side the terminal block is located is marked on the respective side part with the following label according to EN 50438ed1.

- **!WARNING!** There is still voltage on the disconnected cable leads from the solar system even after disconnection from the MPPT input terminals. When disconnected from the input, the cable terminals are at idle voltage, which can be up to about 700 V DC.

- **!WARNING!**: voltage up to 400V DC can appear at the solar input terminals when the PV cable leads are disconnected during operation.
- **!WARNING!** When one of the AC leads “GRID”, “LOAD” is disconnected, voltage from the other side may appear on the individual disconnected terminals, therefore it is necessary to perform a proper shutdown of the equipment.
- Any handling/maintenance is only allowed after the power part has been separated from the connection part.
- Removal of any power component (module) from the plugged-in state from the HES6/10 rack can only occur in the off and de-energized state of the leads and equipment.
- Only persons trained by AERS s.r.o. are authorized to maintain and service the power part (unit / cabling).

During installation/maintenance, care must be taken to tighten the connection terminals to the recommended torque, see Table 1. Improper tightening of the connection terminals can cause thermal damage to individual terminals, instability of the equipment, damage to the equipment and subsequent fire. The correct screw connection also ensures the function of the connection as protection against electric shock.

Table 1:

Recommended tightening torques for screw connections		
Screw dimension	Tightening torque (strength class 6.9)	Use
M3	1.1 Nm	Attachment of printed circuit boards and small structures
M4	2.4 Nm	Structure connecting material, terminals, contacts
M5	4.8 Nm	Rack connecting material, contacts, terminals
M6	8.4 Nm	Rack connecting material
M7	14 Nm	not used
M8	21 Nm	not used
M10	40 Nm	not used

2.6.1. HES station connection – AC cable types

The HES6/10 station is designed to be connected with commonly used conductors in the field of AC distribution connections and in the connection of solar power plants. The following classes of conductors may be used:

- Copper or aluminium solid: round, cable, or single-core wire, but always of the appropriate cross-section
- Copper: round, cable in braided version up to conductor class 4, but always of the appropriate cross-section
- Connecting cables can be at least 6 mm2 in cross-section and must be made with cables of class designation - J-(e.g. CYKY-J 5x6).
- The design of the power leads must be fixed, without moving leads.
- To connect the equipment to the public electricity network, a worker with the appropriate electrical engineering training and the appropriate authorisation according to the Decree, Section 50 is required.

THE HES6/10 STATION IS EQUIPPED WITH CONNECTING TERMINALS FOR AC INPUT / OUTPUT TO THE CROSS-SECTION OF 10 mm2, INTERNAL TRANSMISSION POWER CIRCUITS ARE CONDUCTED BY 6 mm2 CONDUCTORS.

I.e. THE STATION IS DESIGNED FOR MAXIMUM CURRENT TRANSMISSION OF UP TO CA. 32 A. FOR OTHER CURRENT VALUES, AN INDIVIDUAL ORDER MUST BE MADE AND THE CURRENT SIZING OF THE CONDUCTORS USED AND THE PROTECTION AND SAFETY ELEMENTS THAT ARE PART OF THE SYNCHRONIZATION UNIT AND THE INTERNAL CABLING OF THE CARRIER SWITCHBOARD MUST BE ENSURED.

USE OF THE HES6/10 STATION IN ANOTHER CURRENT RANGE AND IN CONFLICT WITH THIS USER'S INSTALLATION MANUAL IS STRICTLY PROHIBITED.

Earthing connection

The HES6/10 station must be permanently connected with a separate earth conductor to the main earthing of the main protective connection.

The cross-section of the earth connection conductor must be at least CYA6 ZŽLm2, preferably CYA10 ZŽL.

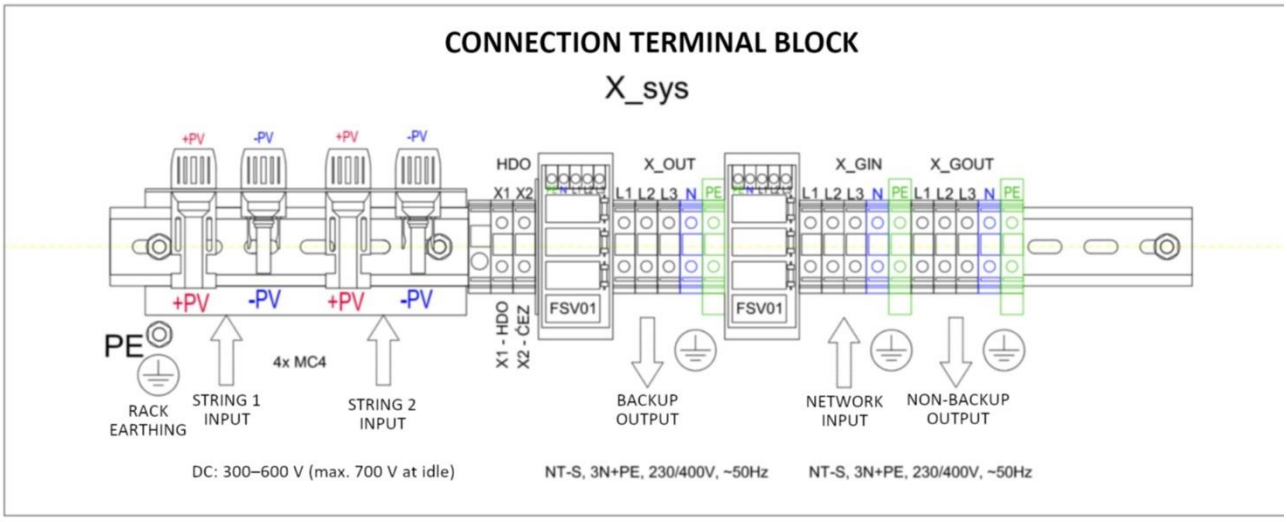
Use of aluminium cables

The connection terminals on the AC side are used to connect the individual aluminium cables. When using aluminium conductors, the rule of one class larger cross-section than for the corresponding copper conductor must be observed.
When connecting aluminium cables, the following points must be met due to the non-conductive oxidised layer of aluminium:

- Rated currents for aluminium cables must be reduced
- The following connection conditions must be met:
    - It is necessary to properly scrape the oxidized layer from the stripped end of the cable – do not use a brush, file or sandpaper for this purpose; the aluminium particles could be transferred to other conductors, ideally use a knife for this purpose.
    - Lubricate the end of the cable with a neutral lubricant after removing the oxidized part. Immediately after lubrication, connect the end of the cable to the terminal.
    - If you disconnect the cable and want to reconnect it, you need to repeat the process.

2.6.2. AC connection design

When connecting AC cables to AC terminals, create loops (arc reserves of individual conductors) on the AC cables. For the connection of AC and DC leads, the HES6/10 station is equipped with a terminal block on the side at the bottom to which the supply and output cables are connected, see figure below. The RSA10 terminals are ready for connection.



!WARNING! The HES6/10 station operates in the mode of supplying phase currents against the middle (zero) conductor (blue), therefore it is necessary to make the correct connection of the individual conductors and to observe the same phase sequence at the inlet (GRID-In) and outlet (LOAD-Out). The manufacturer recommends that the same colour marking and phase sequence be used on all connection terminals, as the phase sequence corresponds to the assignment of the individual conductor colours used at the installation site (according to local practice).

!**WARNING!** If the phase sequence on the cable lead is incorrectly connected (wrong direction of rotation), the power inverter will not be connected to the output and thus no power will be delivered from the equipment. The correction of such a connection is made by mutual reconnection of two phase conductors, e.g. L1 ↔ L3.

!WARNING! Changing the wiring of the three-phase feeders in the building may change the direction of rotation or the function of some three-phase equipment, so it is necessary to check the function of other equipment (HVAC, AC, pumps, etc.) after installation.

Wiring of the power circuits of the HES6/10 station is made in TN-S system: 3 x 230 V/400 V, 50 Hz, therefore during installation it is necessary to maintain the separation of the extreme working conductor N (blue) from the protective conductor PE (green-yellow). In the installation, it is necessary to check the design of the TN-C-S system transition and to check the earth connection and the impedance of the tripping loop.

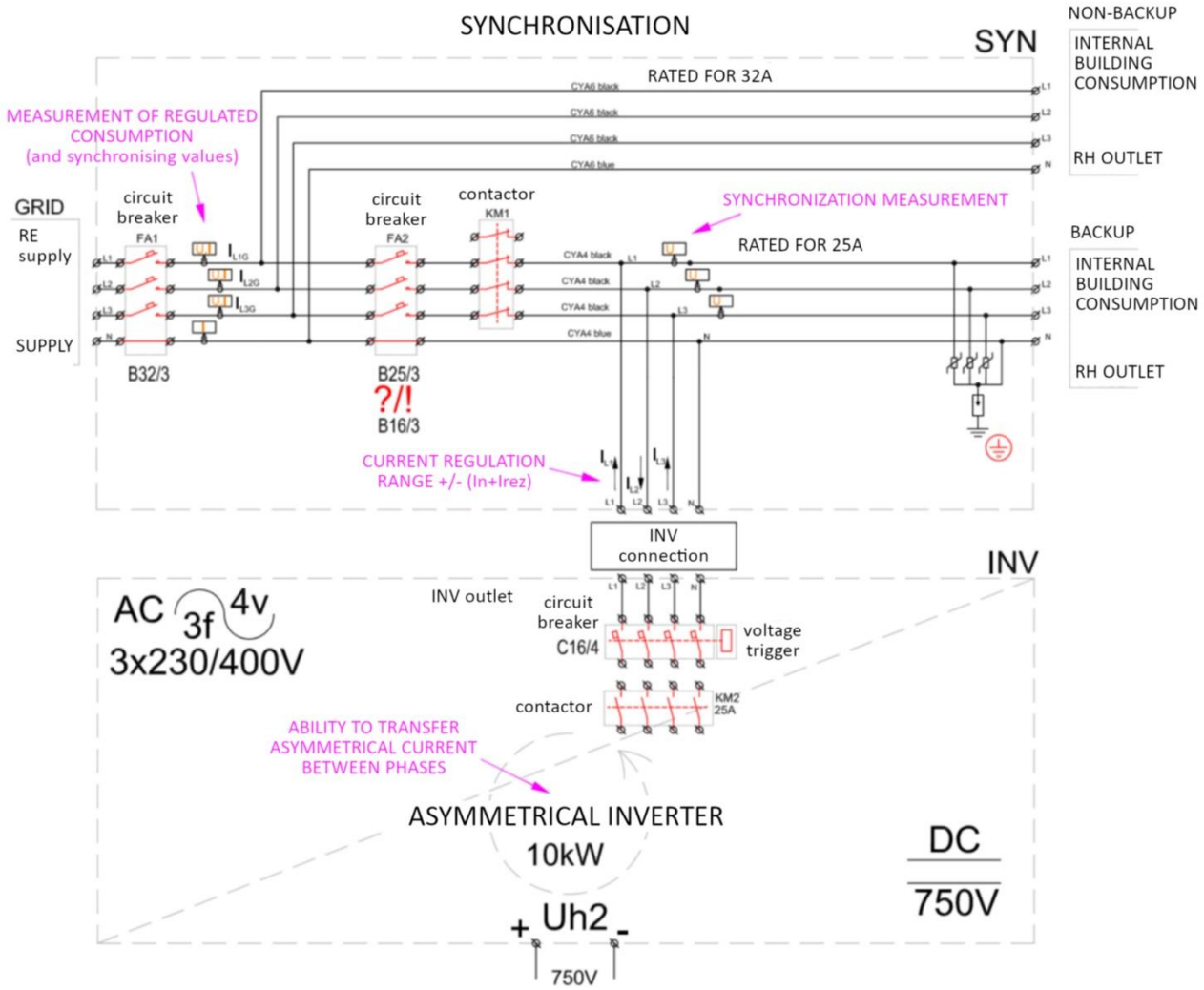
Phase conductors must be in black, brown, grey. The change of the system, i.e. from TN-C to TN-S with a separate PEN conductor, must be carried out in the meter cabinet or before entering the HES6/10 station. The neutral outermost working conductor N must be rated the same as the other working (phase) conductors. If the neutral conductor N is undersized, the inverter may experience a restriction of power supply to the grid or a system failure.

Use of RCDs/RCMs:

The HES6/10 equipment may cause a short-term occurrence of a current with a DC component during transients. If a residual current device (RCD) or a residual current monitor (RCM) is used for protection against direct or indirect contact, an RCD or RCM type B, G with a delay of 10 ms and an inrush current of In: 300 mA is allowed on the supply side of the device (GRID).

When using a current protecting device with a different characteristic in the DN supply, when the station transitions from the backup mode, the home UPS (INTENTIONAL ISLAND MODE), back to the mains connection, the induced pre-charge currents of the input filters may cause undesired tripping of the protector on the supply with low detection current and no delay.

In such an event, the HES station will not be able to reboot and reconnect to the DN after the fault has cleared. The station is equipped with its own residual current detection system, which in the event of a fault disconnects the power part of the station from the DN supply. (EN 62109-2)



The means for disconnecting the AC leads are implemented on the X_sys connection terminal block. This terminal block serves as a single point for the connection of the supply and output cable and the connection of the equipment to the internal installation of the building.

2.6.2.1. Load management inputs

The station is equipped with two load management inputs, which are located on terminals X1 and X2 of the X_sys terminal block. The connection is made by supplying signals from the load management receiver, which is part of the equipment of the meter switchboard at the supply to the building. The connection is made by bringing potential N to the appropriate terminal against phase L1.

Meaning of terminal signals:

X1: Load management – control of appliances in the second tariff
X2: CEZ – signal of ban of energy supply to DN

2.6.3. Connection of the HES6/10 station to solar DC panels (strings)

Safety of connection to solar DC power source

Before starting the installation of the solar panels, the implementation of the inlets of their outputs and the commissioning of the equipment, it is necessary to familiarize yourself in detail with the installation manuals for the individual items of equipment and their parts and the operating instructions for the equipment. Only trained operators are authorised to install solar equipment, provided that they fully comply with the technical requirements set out in the installation instructions. Untrained operators and improper installation can cause damage to the equipment or to the health of the operator.

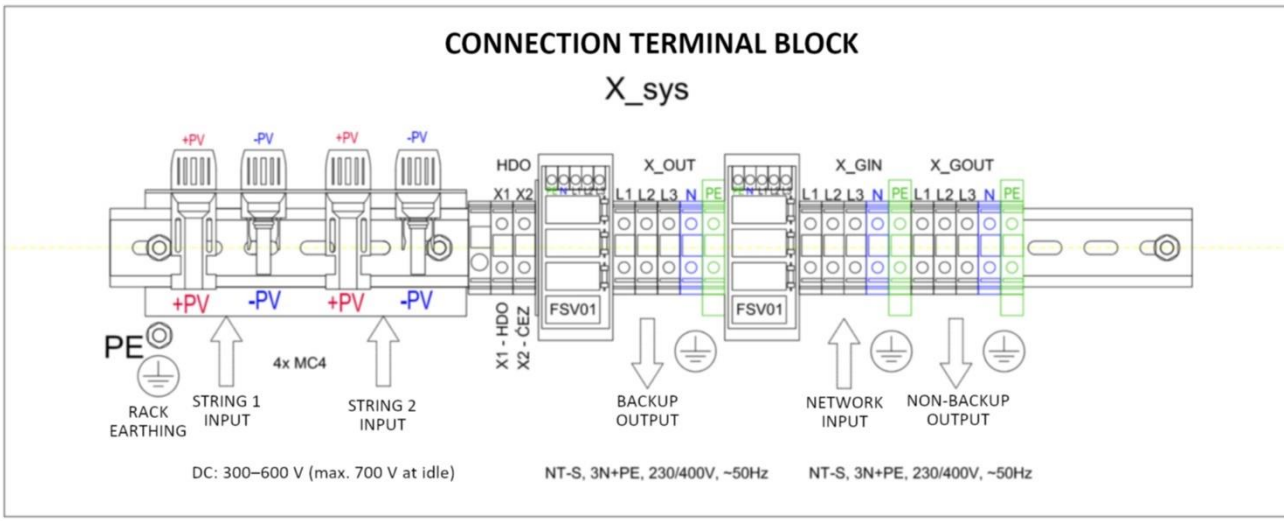
There is a risk of electric shock if the equipment is not handled properly, which can cause injury or death. There is also a risk of shock from mains voltage when handling the equipment and when exposing the PV array to light from the uniform voltage from the solar panels, which can be up to 700–800 V DC at idle.

To ensure safety, ensure that the AC and DC sides are disconnected from the power sources (disconnects, switches, circuit breakers) before any manipulation of the connection. When disconnecting from the equipment that was in operation before the start of the work, it is necessary to observe a pause before further work for 5 minutes after switching off and disconnecting the individual feeders due to the exhaustion of the internal capacities of the equipment.

2.6.3.1. Wires and connectors for connecting solar equipment:

The connection of the solar inputs is made via properly sized cables with double insulation, e.g.:
SOL 6.0 mm2 (black/red); H1Z2Z2-K 6 mm2 (black/red).

The HES6/10 station is equipped with MC4 m+f solar connectors at the position of the side installation rails for connecting solar inputs. These connectors ensure the correct polarity of the solar leads, see figure below.



The means for disconnecting the DC leads are implemented on the X_sys connection terminal block. This terminal block serves as a single point for the connection of the supply and output cable and the connection of the equipment to the internal installation of the building.

Connection with aluminium cables

!The use of aluminium cables for the connection of solar DC leads is prohibited!

2.6.3.2. Connecting solar panel branches to MPPT DC inputs (STRING1, STRING2)

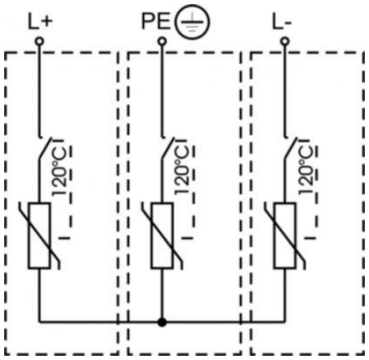
Before connecting, it is necessary to check the polarity and voltage of the solar panel branches, in case of inadequate values of the input parameters of the solar plant (mentioned in chapter 1), there is a risk of damage to the equipment.

The installation design of the solar panels of the rooftop production plant that are intended to be connected to the HES6/10 equipment must be of an insulated design. Before connecting the station to the roof solar panels, the insulation condition must be measured. The insulation resistance value must be > 5 MOhm.

The inputs of the individual STRINGs must be equipped with surge protectors against atmospheric discharges in class II (B) according to IEC 61643-1 on the side of the solar plant before connection to the HES6/10 equipment, with the following parameters:

Max. permanent working voltage DC Uc 1000 V
Max. leakage current Imax 40 kA
Rated discharge current (8/20) In 15 kA
Voltage protection level at In Up < 3.5 kV

The wiring of the surge protector is shown in the figure below:



The voltage of each connected STRING must not exceed the following values:

- When installed at an altitude of 0–2,000 m: 700 V (6 kW/1 input)
- When installed at an altitude of 2,001–2,500 m: 650 V (5 kW/1 input)
- When installed at an altitude of 2,501–3,000 m: 600 V (4.5 kW/1 input)

The SW input power limitation settings must be performed for the altitudes listed.
The current output from the solar power plant must not exceed the specified parameters. See chapter 1.

The individual solar STRING leads must be equipped with fuse disconnectors for 10 x 38 gPV 1000/ max. 20 A (fuse rating must match the parameters of the rooftop panels). This disconnector is also used to disconnect HES6/10 from the DC power supply.

2.6.3.3. Operating parameters of MPPT solar DC inputs of the HES station:

The HES6/10 station is equipped with an input MPPT inverter for the use of the supplied solar energy, which is technically designed to allow parallel operation of multiple input MPPT inverters. These solar inputs are installed in the MPPT module unit (harvester), which is equipped for mounting two input inverters in the basic version. The parameters for each single solar input are:

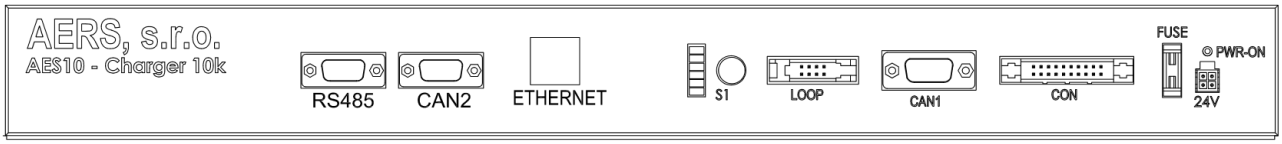
Operating voltage range per PV input: 300–600 V DC
Maximum voltage at idle: 700 V DC

Max. current per 1 PV input: 20 A
Max. power per 1 PV input: 6 kW
Within this range, the voltage and current parameters of each connected solar input must be met. The HES6/10 can only be used with panels with the Solar IEC 61730 standard **class A**.

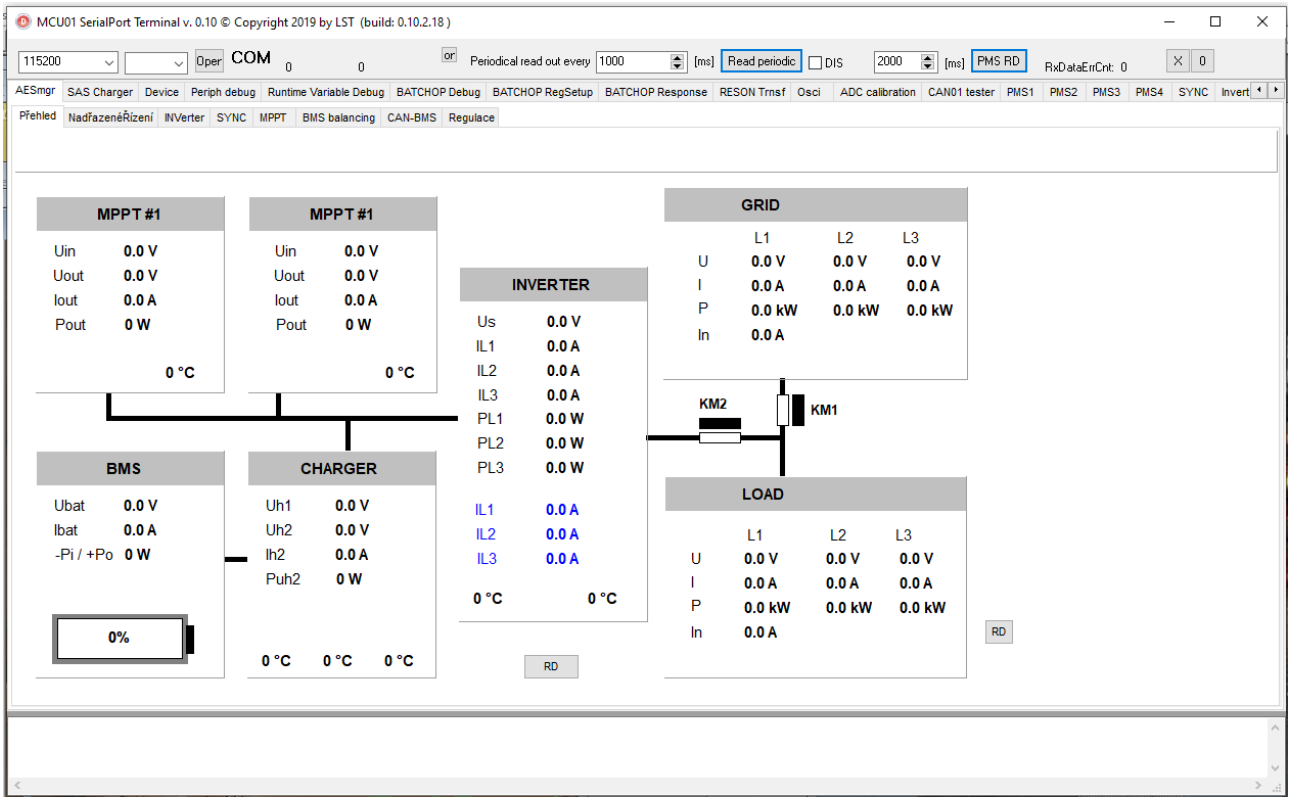
2.7. Wired connection of diagnostic access to HES6/106/10: Ethernet – WEBklient

The HES6/10 station is equipped with an Ethernet communication interface of the TCP/IP standard for diagnostic monitoring purposes. The connection connector is located on the front panel of the Charger unit (position 21, parts description). The Charger unit provides control management of the energy flow inside the station and is equipped with a WEBklient service for diagnostics purposes, designed to provide data transfer in visual form for common web browsers.

In order to make this service available, it is necessary to install a data cable in the HES6/106/10 station to the connector at position 21 and to connect this cable preferably to a data router or switch of the local data LAN. Or a direct connection can be made to a tracking computer with a suitable internet browser using a crossover data cable.
Recommended data cable type: FTP Cat5e. Note that the maximum length of the data link cable is 105 m according to the LAN TCP/IP specification.



Service software:
For service and debugging purposes, the station is equipped with the “Debugging and Service Application – “MCU01 SerialPort Terminal v 0.10”,” which is intended exclusively for authorized professional service technicians. The connection of the service application is made via the RS485 service serial port in the Charger unit.



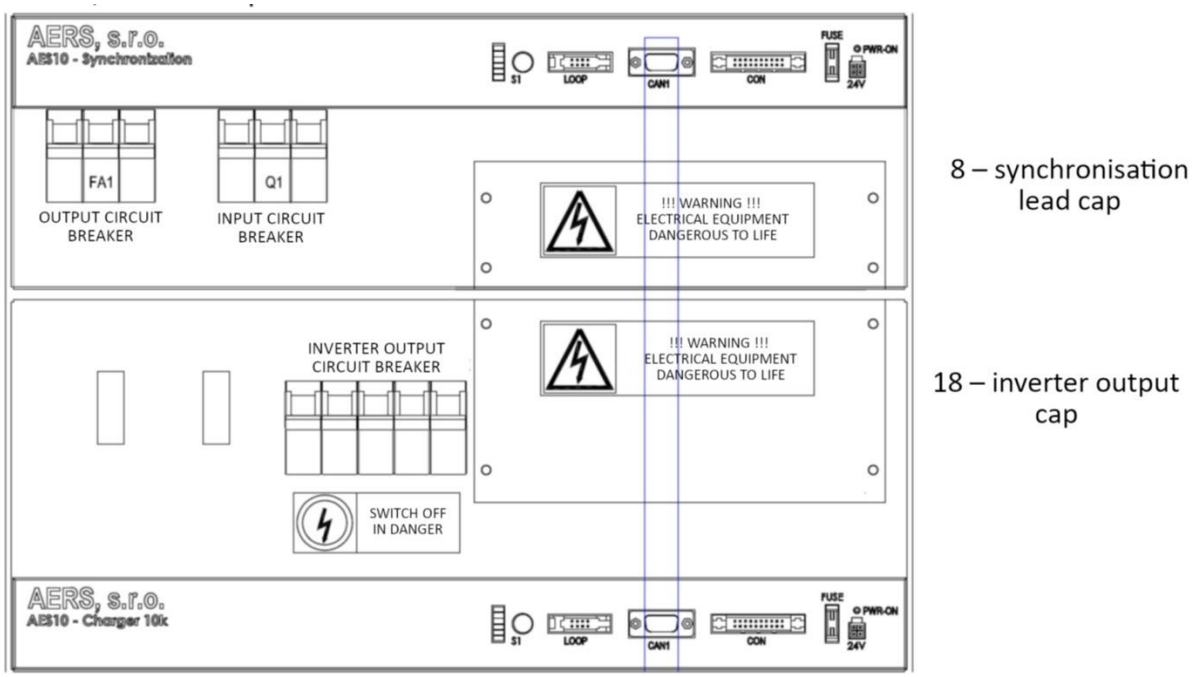
3. Commissioning

Check before commissioning:

Before starting the installation and commissioning of the equipment, it is necessary to check the individual inlets and the way they are designed, see the previous sections of the document. It is essential to read the installation and operating instructions for the equipment carefully. Only trained operators are authorised to install the equipment, provided that they fully comply with the technical requirements set out in the installation instructions.

BEFORE THE STATION IS PUT INTO PERMANENT OPERATION, AN INITIAL INSPECTION OF THE ENTIRE ELECTRICAL INSTALLATION MUST BE CARRIED OUT REGARDING THE CONNECTION OF THE HES6/10 STATION TO THE INSTALLATION.

IN ORDER TO PERFORM THE IMPEDANCE MEASUREMENT OF THE TRIPPING LOOP WHICH IS PART OF THE REVISION AND WHICH IS TO BE PERFORMED WITH THE OUTPUT 3f_ INVERTER TERMINALS DISCONNECTED, THESE TERMINALS BETWEEN THE INVERTER AND THE SYNCHRONISATION ARE MADE AVAILABLE. BEFORE COMMISSIONING THE EQUIPMENT IT IS NECESSARY TO COVER THE COVERS, SEE positions 8 and 18 in the chapter on the contents of delivery. The covers are equipped with safety labels reading “WARNING, Electrical equipment, dangerous to life”.



3.1. Commissioning procedure

Before commissioning, it is necessary to check the connection of all units with CAN1 and CAN2 communication cables. The connection of the battery section with the AcuPacks to the Charger unit is made via a CAN2 communication link. The connection of the Charger (CHA), MPPT, 3f_Invertor (INV) and Synchronization (SYN) power units is made via the CAN1 communication link. All units in the station assembly are connected via the LOOP signal bus and the Charger unit is connected to the SwitchBoard unit by a flat IDC control cable.

It is also necessary to check the switching on of all circuit breakers located on the front panels of the units and to check the fitting of 125A fuses in the MAIN DISCONNECTOR.

WARNING: The Q1 -BYPASS switches must be in the OFF position (downward direction) when they are first started and the status locked by the plastic pull-out fuse must be checked. Or they must be in a position that results from the customer configuration of the system.

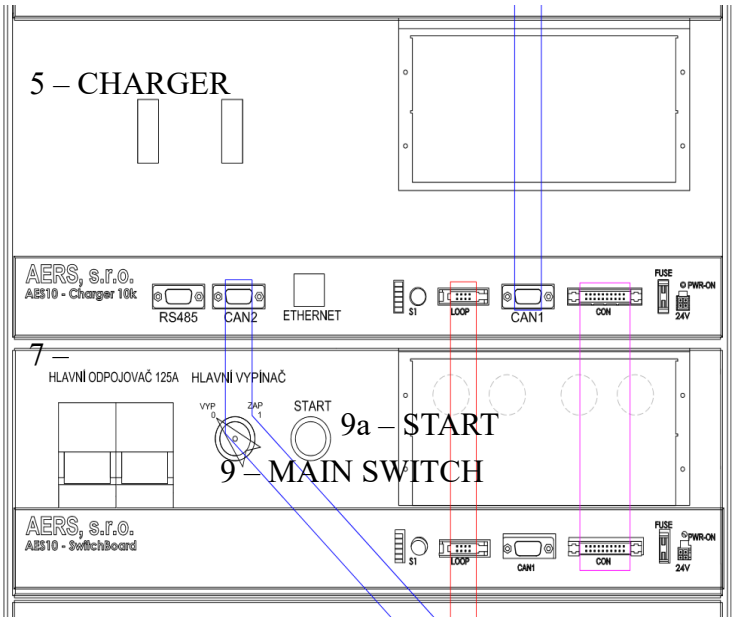
It is also necessary to check that all units are firmly screwed into the equipment rack, especially at the points marked with the earthing symbol. These screw connections ensure that all functional parts of the equipment

are connected together and that they are thoroughly connected to earth as protection against dangerous contact. Check the tightening torque, see Table 1.

3.1.1. Starting the equipment:

The HES6/10 station is commissioned by turning on the MAIN SWITCH, which is located on the front panel of the SwitchBoard unit, see the figure below, position 4: 9 – SwitchBoard: MAIN SWITCH, position 5 – CHARGER. By switching on the MAIN SWITCH, the 24V power supply is internally connected to the battery part of the station. Starting the station is done by pressing the START button (9a), which is used to connect the system (on-board) 24V power supply to the control circuits, which already hold the power supply voltage in a controlled manner to ensure the running of the station. The running of the station is signalled by the green light of the START button (9a).

When the 24V is switched on, voltage is supplied to all control units in the station system and the parallel sequences of equipment start-up are initiated. The block diagram is shown in the figure below:



The station is set to the default settings from the manufacturer. For user monitoring of the operation and status of the station setup, a local intranet application WEBklient is designed, which is accessible through a standard web browser when the HES6/10 station is connected to local LAN. Service level adjustments may only be carried out by a trained person. The “MCU01 SerialPort Terminal v 0.10” serial service application is used for this setting.

The switch-on sequence is accompanied by successive switching processes and signalling on the panels of the individual units. The main switching process that is triggered when the 24V MAIN SWITCH is switched on is the start of the CHARGER control unit, which checks the system status and battery charge in the AcuPack units. As part of the batteries connection, a sequence of pre-charge circuits of the boost converter filter is made so that high pre-charge currents from the batteries are avoided. After the boost converter is pre-charged, the main power contactor switches on. This sequence takes about 3–5 seconds. After pre-charging the boost converter intermediate circuit, the CHARGER starts the resonant converter of the main intermediate circuit Uh2, which is stabilized at 750 V DC.

Through the intermediate circuit Uh2, power is transferred from the solar inputs of the MPPT to the output inverter or to the batteries. After this start-up sequence, the HES6/10 station checks the insulation status of the solar feeders by leakage current detection. When a good isolation condition is evaluated, the station detects the BYPASS switch setting status.
After this detection, the station connects the supply network with contactor KM1. It then connects the outputs of the 3f_Invertor power inverter to the KM2 contactor and starts up in the parallel operation mode according to the DN, as prescribed in EN 50438ed2.

The start-up and mode of the station is further governed by the operating mode setting from the previous start-up/setup procedure.

3.1.2. Start-up and connection according to ČSN EN 50438ed2:

“Connection and start-up of power generation is only permitted if the voltage and frequency are within the permitted voltage range and the permitted frequency range for at least the observation time. These conditions must be reversible. The setting of the conditions depends on whether the connection is due to a normal operating condition or to automatic reconnection after the interface protection has been disabled.”

Automatic reconnection after switching off

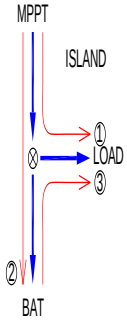
The HES6/10 station has been set to enable connection to the DN in the frequency range: 49 Hz to 50.05 Hz and a permissible voltage range of Un: 0.85 Un to 1.1 Un. The network monitoring time before connection is 60 seconds. These settings can be adjusted according to local DN conditions or national requirements.

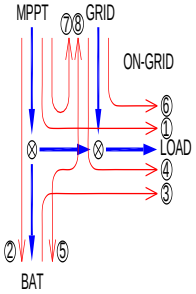
Start of power generation:
The HES6/10 station has been set to enable connection to the DN in the frequency range 49 to 50.1 Hz and the allowed voltage range of Un: 0.85 Un to 1.1 Un. The network monitoring time before connection is 60 seconds. These settings can be adjusted according to local DN conditions or national requirements.

3.2. HES6/10 operating modes

The modular concept of the HES6/10 stations allows individual customer configurations to be tailored to local operating conditions and enables combination of the equipment with other technologies. The layout and configuration of the HES6/10 station allows the following operating modes, which ensure maximum utilisation of generated energy for the operator's own needs and minimise the consumption of energy from the distribution network, for example in the high tariff. The main operating modes are:

1) island mode – ISLAND and 2) operation mode parallel with the network – ON-GRID.





In these modes, the individual energy flow directions, control modes and transitions between these modes are handled with the specified priority weighting as follows:

(1) *PV (MPPT) → Load*
(2) PV (MPPT) → Bat
(3) *Bat → Load*
(4) *Grid → Load Symmetrisation (load asymmetry compensation (phase overload))*
(5) Grid → Bat
(6) *Grid → Load*

Option:

(7) PV (MPPT) → Grid
(8) Bat → Grid

3.2.1. Description of individual mode properties

(1) PV (MPPT) → Load is the operating mode in which the energy obtained from the solar source "PV MPPT" is directly transferred to the output of the power inverter by converting DC to AC and through the Synchronization measuring and switching unit to the operator's consumption circuits. The instantaneous power transferred to the load is determined by the capability of the solar resource (its power) and the instantaneous demand of the load, i.e. the appliances currently in use. The HES6/10 station also allows the external controlled outputs connected to the RS485 bus (MODBUS RTU) to switch on an external device that can implement controlled consumption in case of excess energy from a renewable source (for example: heating of DHW and heating, or running of pumps, compressors...) Due to the above conditions, this mode is directly related to the second mode:

(2) PV (MPPT) → Bat, in which the energy produced from the solar source is transferred and stored in the batteries by direct conversion of the DC voltage level. These two modes are primarily preferred to maximize the use of the energy produced for the operator's needs.

This mode is immediately followed by controlled priority load switching, which is used to switch on the appliance(s) to ensure at least a partial (or complete) transition to mode (1) and consumption of the energy produced for energy-intensive tasks such as heating of DHW and heating. The switching of these appliances is evaluated based on the state of charge of the batteries. In normal operation, there is regular switching between these modes depending on the daily situation.

(3) Bat → Load. In this mode, the energy (DC) stored in the batteries is fed to the output of the 3f power inverter (AC). The output inverter has the built-in ability to deliver different power on each phase. The nature of the output power delivery depends on the operating mode of the inverter, whether it is the ISLAND mode or ON-GRID mode. In each of these modes, the output inverter operates in a different control mode. In ISLAND mode the inverter operates in output voltage regulator mode and in ON-GRID mode in output power (current) regulator mode.

In ISLAND mode, the power delivered at the inverter output is determined by the connected load up to the maximum power level, which is determined by the overload capacity of the individual parts of the station. Shutdown of the 3f inverter outputs will occur at high power consumption due to increased heating of the elements inside the equipment. The shutdown is done by switching off the outputs.

In the ON-GRID network parallel operation mode, the output power is controlled depending on the instantaneous measured values of the current drawn from the network, the state of charge of the batteries, the strength of insolation and the PV power and based on the set time control of the station. Measurement of the instantaneous power rating of the current drawn is provided by the Synchronization unit.

(4)Grid → Load Symmetrisation (load asymmetry compensation (phase overload)). In this mode, the power output of the 3f inverter allows the current drawn on each phase to be adjusted to the set value. The inverter allows to supply current in parallel to the phase which is overloaded by current from other phases which are not so loaded, or by current from the solar input or from the batteries. Measurement of the instantaneous power rating of the current drawn for the LoadSymmetrisation mode control is provided by the Synchronisation unit.

(5) Grid → Bat. In this mode, energy from the grid is used to charge the batteries. This mode is used, for example, to use the current in the low tariff to charge the batteries for other regulation processes, such as covering peak power draws caused by a coincident event.

(6) Grid → Load. In this mode, the supply of current from the distribution network to the load circuits is ensured. The power circuits of the inverter are connected in parallel in the HES6/10 station to provide power to the load and to the distribution network as described in Section 3.2. HES6/10 operating modes. The actual control of the grid connection is controlled and provided by the Synchronization unit, which enables the transition to the appropriate mode according to the customer settings and the status of the grid.

Other operating modes of the equipment can be set as individual customer modes in the controlled delivery of generated energy towards the distribution network.

(7) PV (MPPT) → Grid. In this mode, the solar energy produced is fed into the distribution network. This mode is activated when the batteries are fully charged and the energy is used for other controlled switching appliances.

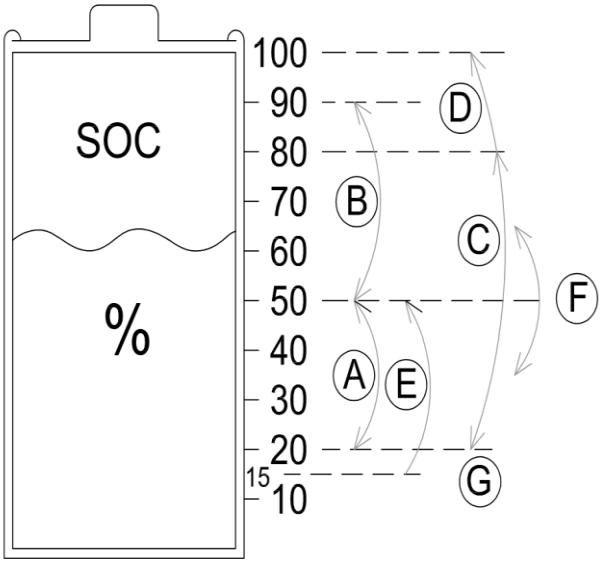
(8) Bat → Grid. In this mode, the energy stored in the batteries is used to supply power to the grid. This mode is designed for the use of the HES6/10 station for the regulatory needs of the network operator, or the synergy of a larger number of HES6/10 stations installed in a cooperating system.

These modes and transitions between them are controlled automatically by the HES6/10 Master Station Control System, which is part of the SW equipment. The transition conditions between the individual processes are determined by setting of the operating parameters and are linked to the current ratio between consumption, solar generation and battery charge level, see “setting the station parameters”.

3.2.2. Setting the master control for AUTOMATIC RUNNING

The automatic running of the HES6/10 station is controlled by setting the basic parameters for the battery capacity utilization (SoC – State of Charge), the current state of supply capability from the solar power source (PV) and the current state of household consumption. These parameters control the operation of the user’s storage station, with the exception of the lower cell charge limit (15–20%), which is protected by the manufacturer to preserve the life of the installed battery.
The charge level, capacity, battery, SOC, is divided into individual ranges in which a certain functional mode of energy use is preferred in terms of the overriding control of the regulation. Each building is unique due to its individual use and therefore needs its own settings of operating modes.

The basic (recommended) setup model with respect to battery usage at each capacity level is shown in the figure below.



(A) – Range of 20 to 50% SOC. This range is intended for the capacity reserve of the station operation in island operation or in the operation of controlled compensation of grid consumption in times without solar energy (reduction of the power drawn from the grid, at high coincidence).
(B) – Range of 50 to 90% SOC. This range is designed to compensate for the power drawn from the grid in any range and the excess power is fed into the grid if necessary.
(C) – Range of 20 to 80% SOC. This range is designed to recharge the batteries with the power supplied by the solar plant. In this range, the batteries are recharged with the recommended PV charging current (if available).
(D) – Range of 80 to 100% SOC. In this range, the charging current is reduced in the charging mode from the solar plant by the BMS control.
When the batteries are discharged to the 20% SOC limit, the station goes into a reduced power mode (G) with reduced consumption (DeepSleep) in case of lack of energy from the solar panels, in which it waits for the opportunity to charge again from the solar panels. If in this mode the SOC level drops to 15%, the station enters a mode (E) in which it charges the batteries up to 50% SOC by drawing power from the grid.
The weather forecast mode is introduced into the higher-level control by setting a limit (F) for the reserved energy mode and grid power compensation.

The default settings of the station behaviour are done by the manufacturer. A user interface in which the default settings can be modified is available to the user.

4. HES station maintenance.

The HES6/10 is designed as an automatic station with minimal maintenance requirements. However, it is necessary to ensure suitable operating conditions within the operation.
Maintenance operations include ensuring a clean environment.
As part of the maintenance, it is necessary to ensure regular removal of cobwebs and dust from the intake and outlet grilles and cleaning of the front panels of the internal devices accessible after opening the equipment door. Clean with an ESD brush and a vacuum cleaner.

The recommended frequency of regular maintenance is at least once a year.

Maintenance work must only be carried out by a person trained in these tasks and extra care must be taken when handling tools in the vicinity of controls and individual connector locations.

IN THE EVENT OF A FAULT CONDITION, IT IS NECESSARY TO ARRANGE FOR PROFESSIONAL SERVICE INTERVENTION BY THE SUPPLIER OR A TRAINED SERVICE COMPANY. ¶

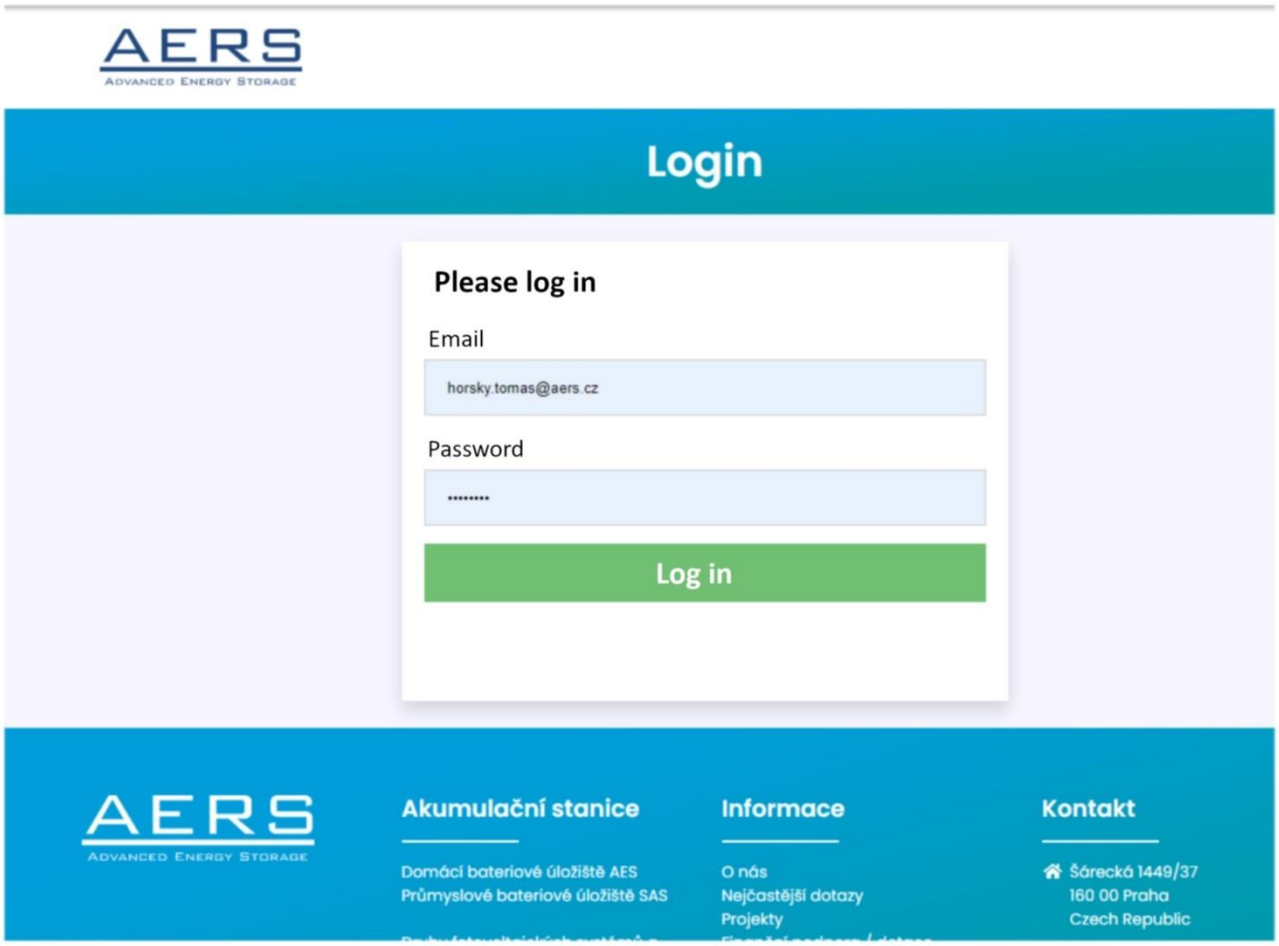
5. Connection to customer and service SW interface

¶The HES6/10 station is equipped with an Ethernet communication interface for customer needs, which is automatically connected to the customer visualization WEB application, which is available for each commissioned HES6/10 station on the AERS web portal.

The customer service address is: **https://aes.aers.cz/**

5.1. Login

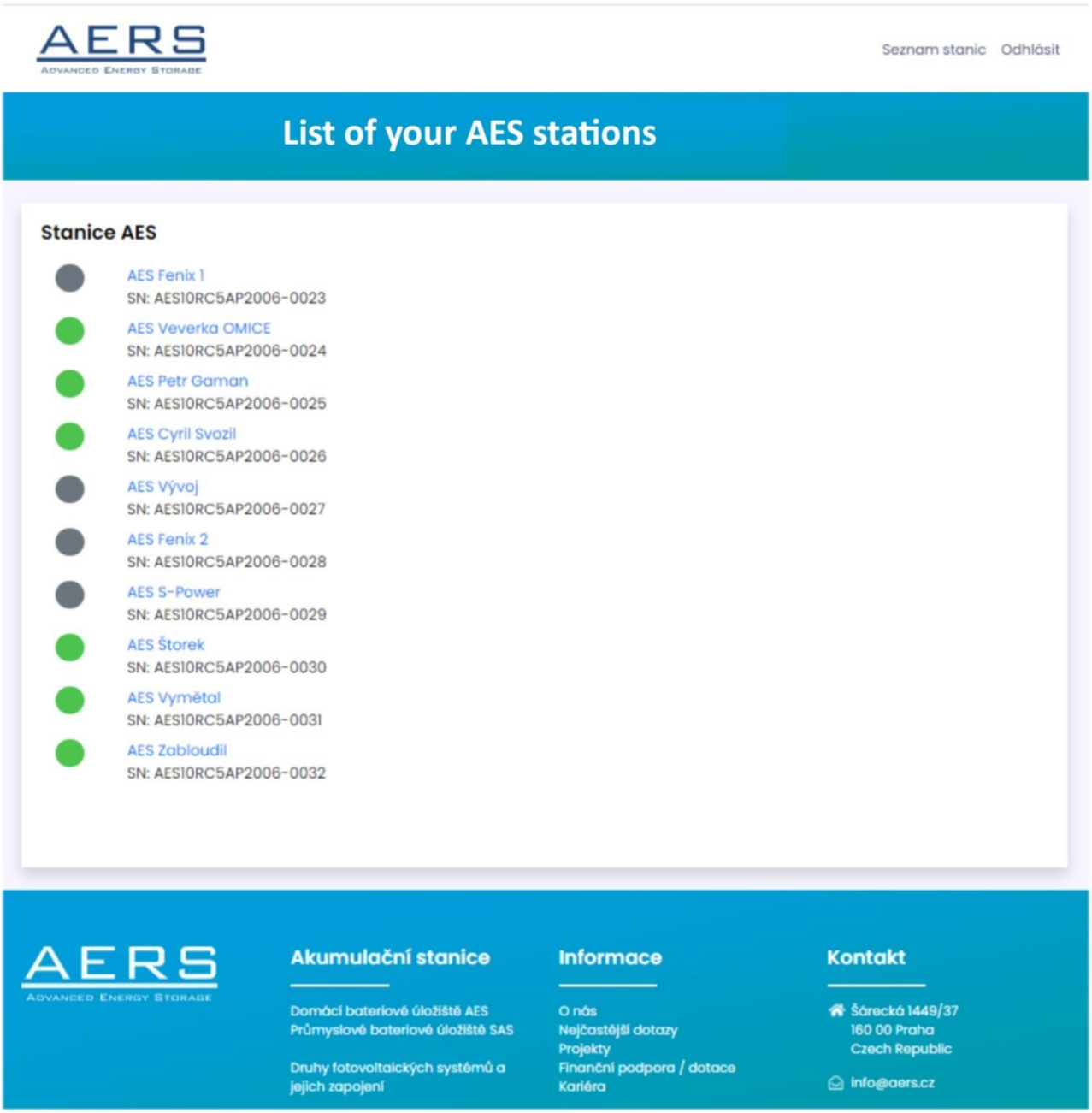
An active username and password are required to access the customer web application. The access interface is shown below.



A customer account is generated for each user when the equipment is delivered and installed.

5.2. User portal

The user portal offers access to the individual HES6/10 stations that the user has in active use.

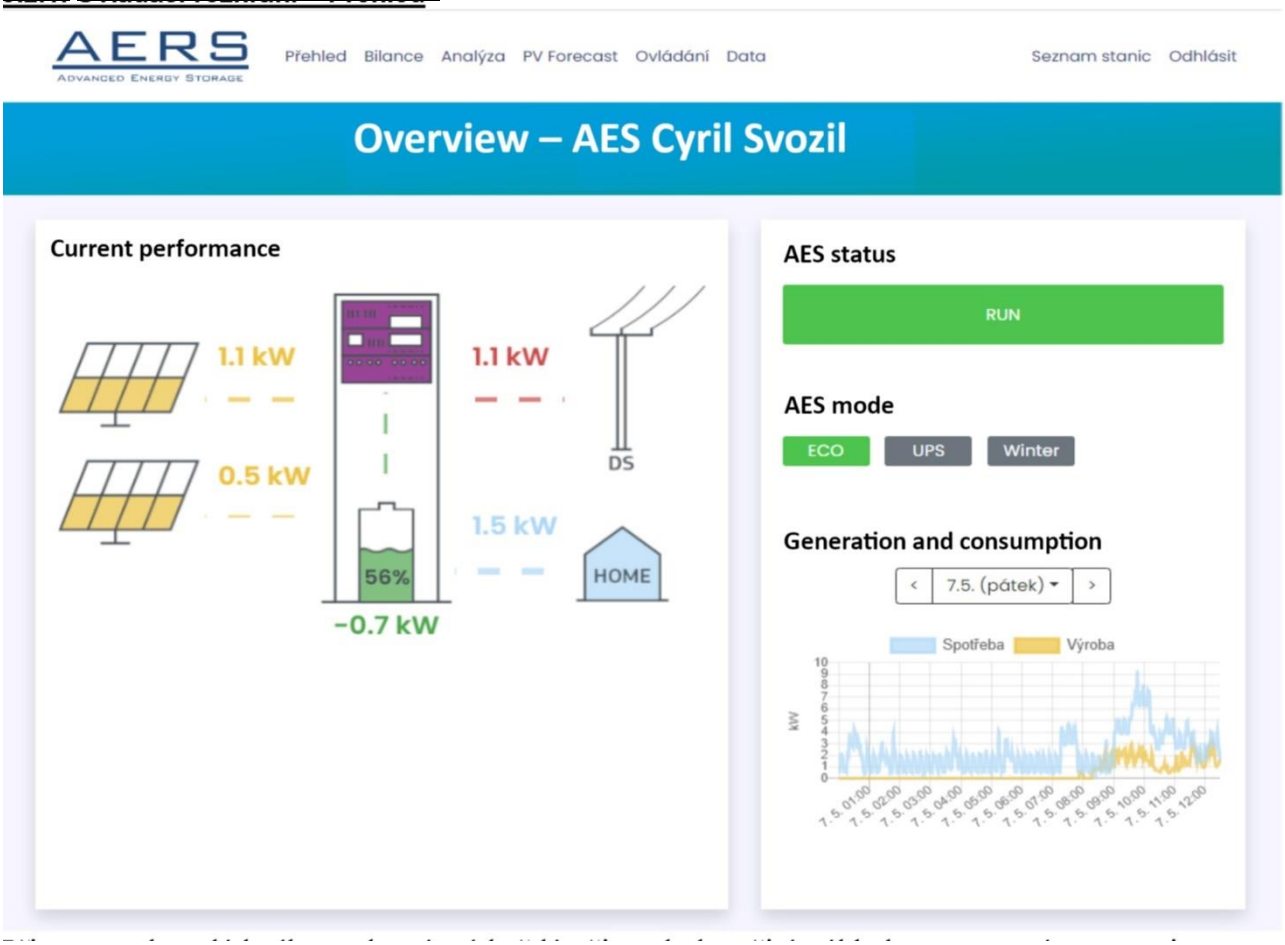


The operational status of each station that the operator has connected is shown by a coloured symbol in front of the project name.

Selecting a specific station takes the user to the main station page where the current overview of operating variables is displayed. The following subpages are also available to the user:

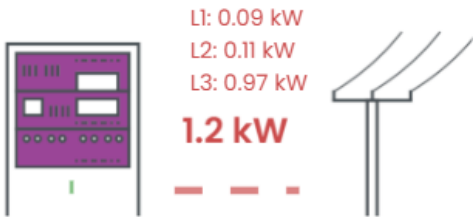
- Overview, *chapter 5.2.1.*
- Balance, *chapter 5.2.2.*
- Analysis, *chapter 5.2.3.*
- PV Forecast, *chapter 5.2.4.*
- Controls, *chapter 5.2.5.*
- Data, *chapter 5.2.6.*

5.2.1. Control interface – Overview



When entering the control interface, each user has an immediate view of the operational status of the station, which is shown on the "Overview" page. On this page, the instantaneous values of the operating variables in minute average are shown in individual blocks. A negative sign on the power display for batteries indicates charging at the indicated power.

"Current performance" – this block shows the values of the average minute waveforms. For AC lines, the user can preview the power on each phase. The display is performed when the mouse cursor is placed on the displayed values of the DN (Distribution Network) outputs and HOME. An example of an opened performance listing is shown in the figure below.



"HES6/10 status" – this block shows the current operating status of the station. ¶The displayed states are:

condition:	colour coding:	description:
RUN	GREEN	The station is operating in one of the set operating modes
SLEEP	ORANGE	The battery state of charge, or set mode, has put the station into a standby mode in which it is monitoring the available solar input power and operating conditions so that a charging mode, or another form of power delivery, can be initiated.
OFF	GREY	The station is in the off state
ERROR	RED	The station is in a state of failure.

“HES6/10 mode” – in this block the user has the option to switch the station to a predefined operating mode. The set mode determines the ability to react immediately to sudden events and also affects the internal consumption of the station. The internal consumption is covered by solar inputs or by the distribution network (DN). The current operating status is shown by the coloured illumination of a specific sign. To change the settings, click on a specific sign. When a change is entered, the control change may be delayed by up to 120 seconds between the time of entry in the app and the station due to internet traffic. The ongoing change of settings is signalled by the coloured background of each mode.

The colour indication of transitions when changing settings includes the following states:

	colour:	condition:
	GREEN	Current operational status
	ORANGE	A state change command has been executed, the application is waiting for confirmation of the change
	GREY	Inactive state

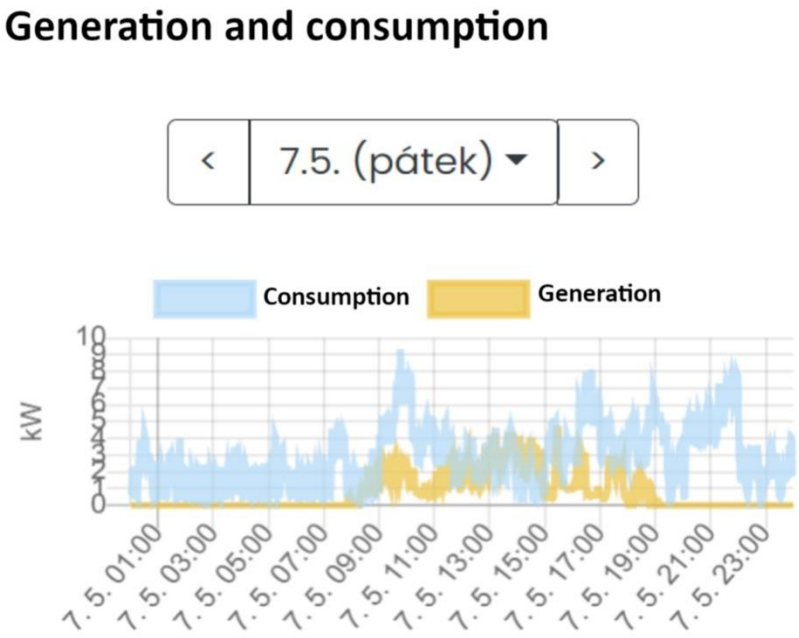
The meanings of the individual modes are as follows:

ECO – In this mode, the station optimizes its operation with an emphasis on reducing internal consumption. The station transitions into the “Deep-Sleep” mode in which the pulses to the power switching elements are switched off. The transition to the Deep-Sleep mode occurs when there is no supply from the solar PV panels, the battery charge level drops below D – SOC set on the Control page and the average household consumption is below 750 W. In this mode, the station switches to the ISLAND mode in the case of a network failure with an interruption and delay of 25 seconds.

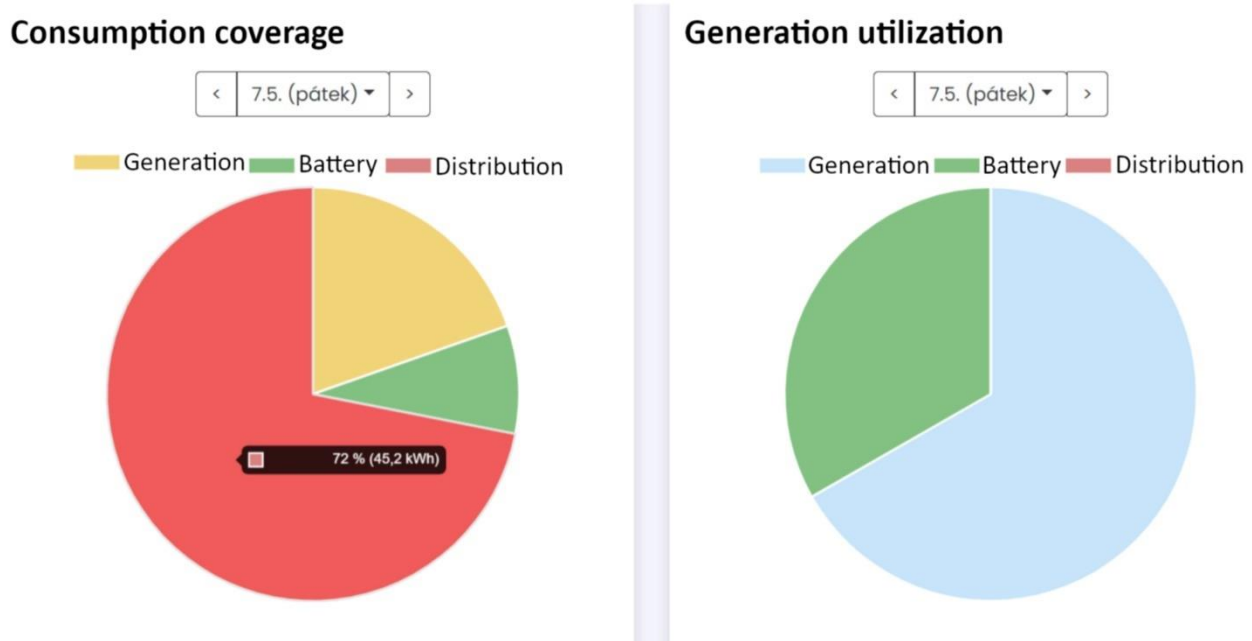
UPS – In this mode, the station is constantly connected and ready to switch to the ISLAND mode in case of a network failure. The station’s own consumption is taken from the grid

Winter – In this mode, the station enters the Deep-Sleep mode as in the ECO mode and switches on only when energy is supplied from solar PV panels or when there is a power failure with a delay of 25 seconds. This mode is suitable for the winter when insolation is low and the station works so as not to discharge the batteries.

Generation and consumption – Another user tool on the “Overview” page is a daily graphical representation of the generation and consumption performance of the building. The graphic shows the individual waveforms in minute averages. When the page loads, the current day is always displayed and the user has the option to select individual days back in time.



Another graphical representation are pie charts that show statistics of the actual daily coverage of the building self-sufficiency in generation and battery capacity.



The “**Consumption coverage**” diagram shows how much the different sources, i.e. the distribution network, the solar panel generation and the energy stored in the batteries, contributed to the consumption of the building. The user has access to the exact values of the averages by placing the cursor on a specific area of the diagram.

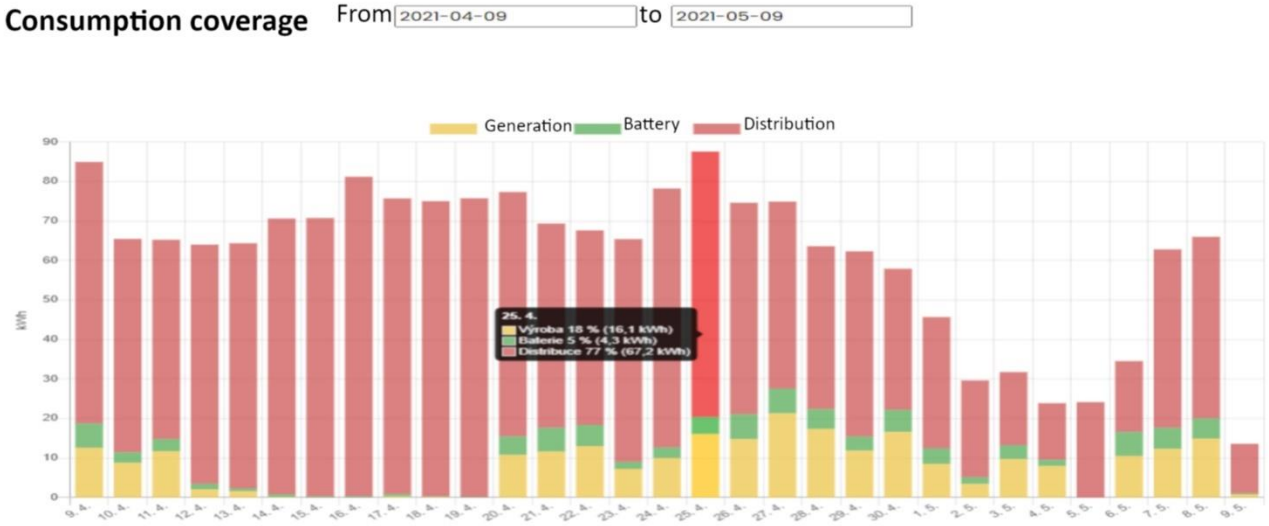
The second diagram – “**Generation utilization**” – shows what percentage of the solar energy produced was used within the day, i.e. what percentage of the energy produced was stored in the batteries and how much of the energy produced was immediately transferred to the household or to the distribution network.

The “**Overview**” page also contains news from the operation of the station manufacturer, AERS s.r.o.

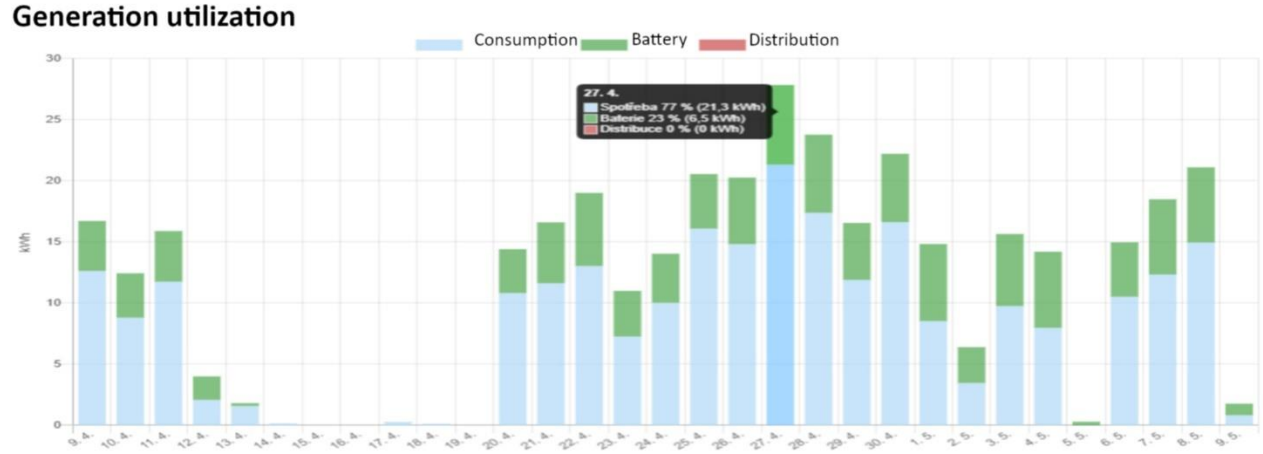
5.2.2. Diagnostic interface – Balance

On the "**Balance**" page, a statistical comparison of the individual daily results of the energy sources **[kWh]** for the selected period is available to the user. The basic setup works with the current 30 day records and the user has the option to select a custom time window for display. The displayed graphical outputs are:

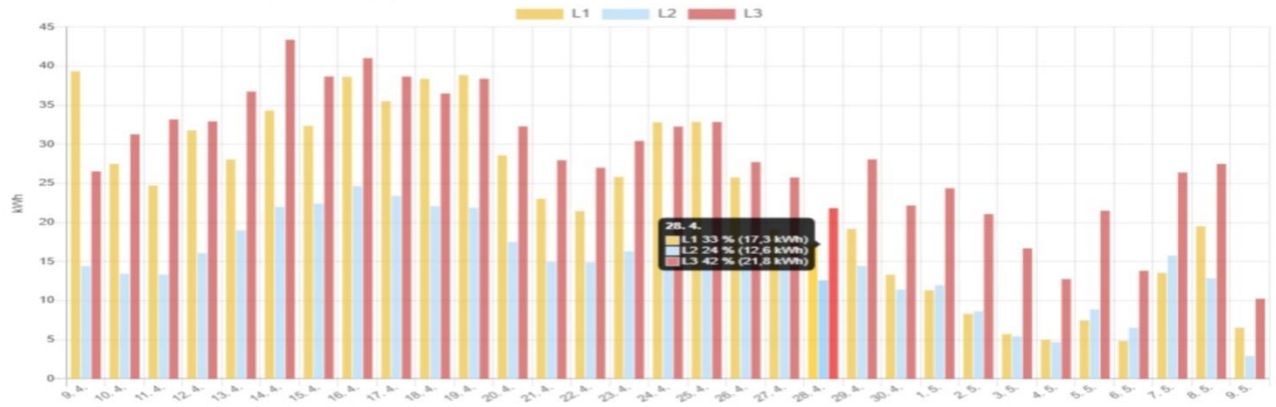
- Consumption coverage – graph of long-term generation usage compared to grid consumption.



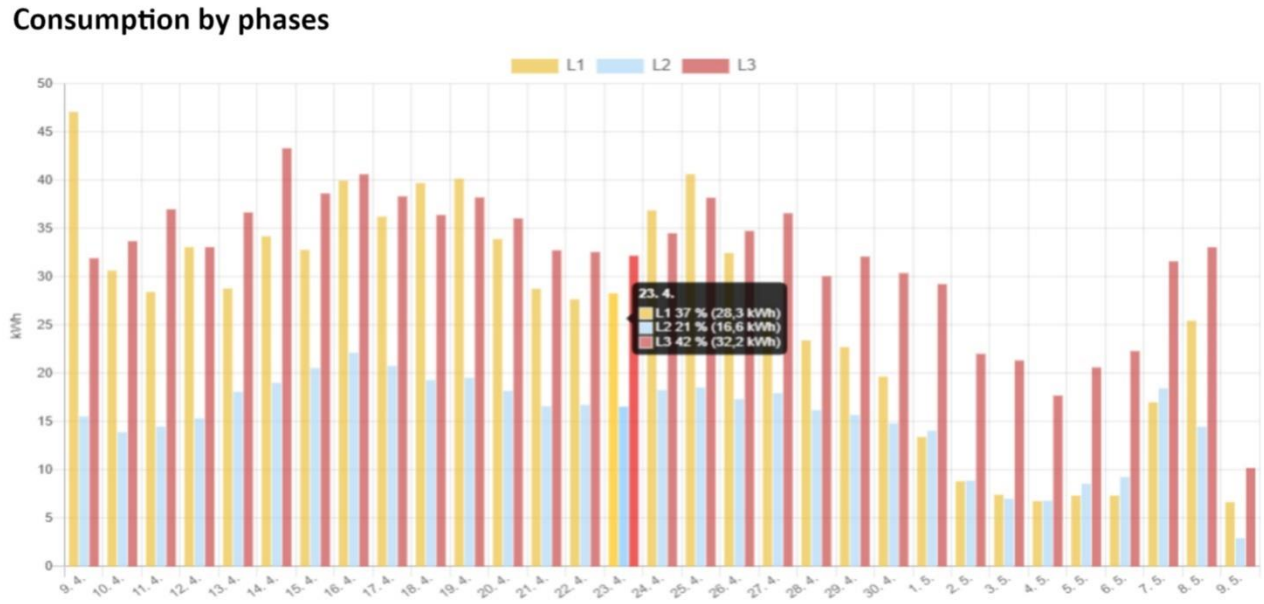
- Generation utilization – graph of long-term generation utilization.



- Distribution consumption by phases – graph of long-term distribution of DN consumption by individual phases.



- Consumption by phases – graph of long-term distribution of consumption inside the building by individual phases.

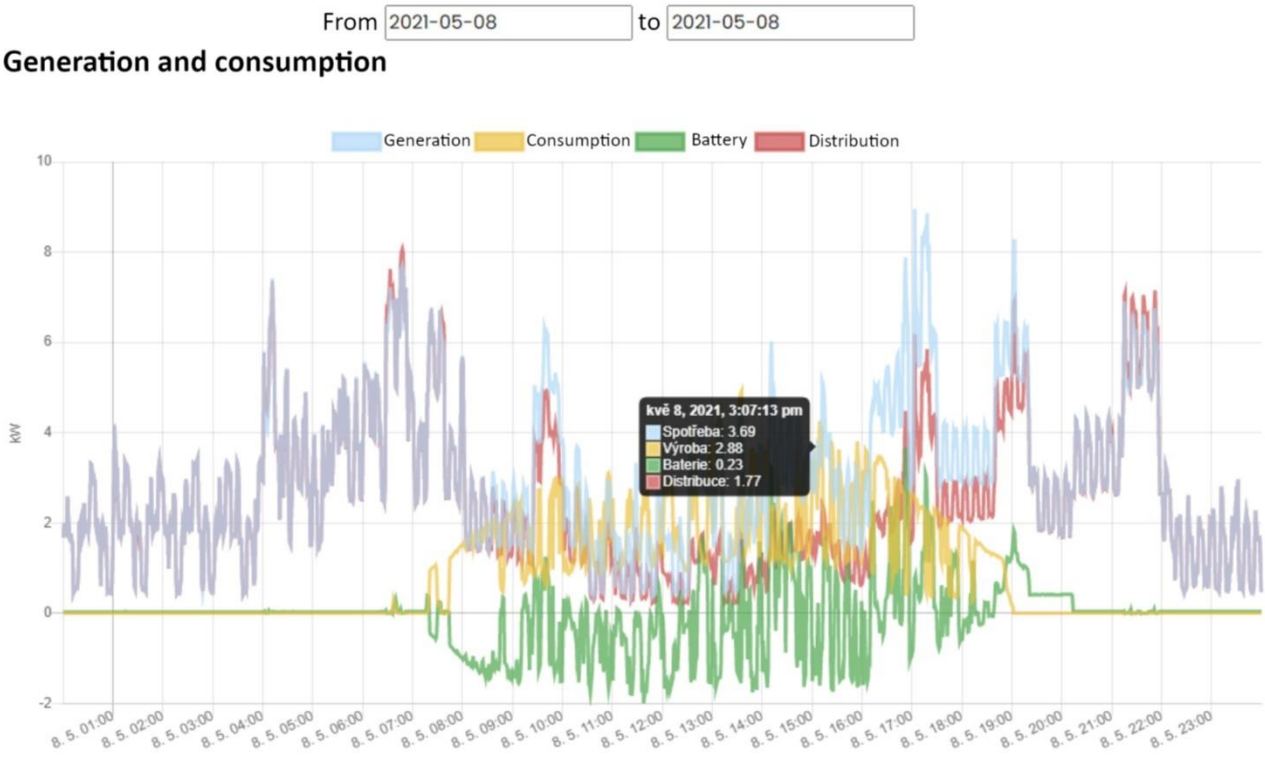


The difference of values in the individual graphs “Consumption by phases” and “Distribution consumption by phases” represents the energy delivered to each phase from its own generation.

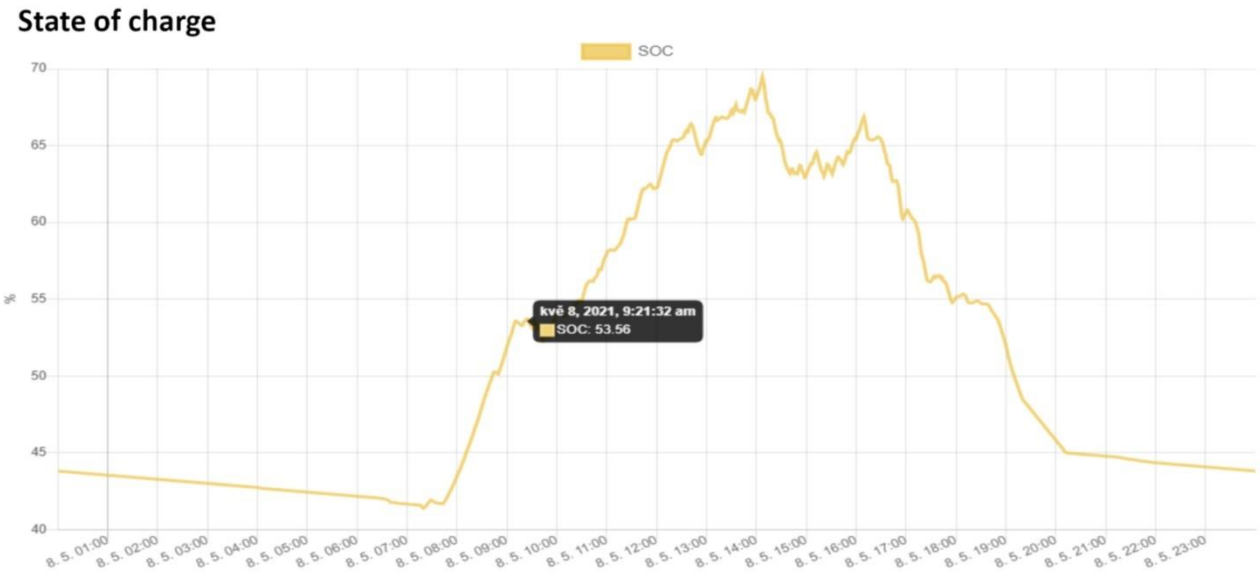
5.2.3. Diagnostic interface – Analysis

On the “**Analysis**” page, the user can see the minute averages of the power **[kW],** that occur in the household. From this graphical data, the user is able to diagnose the power load of individual phases, parallels and overloads. Based on the above charts, the user can make an adjustment in the wiring and / or an adjustment in the control of the wiring or selected appliances. The basic unit displayed is the current day, the user has the option to adjust the displayed time interval as required. The displayed graphical outputs are:

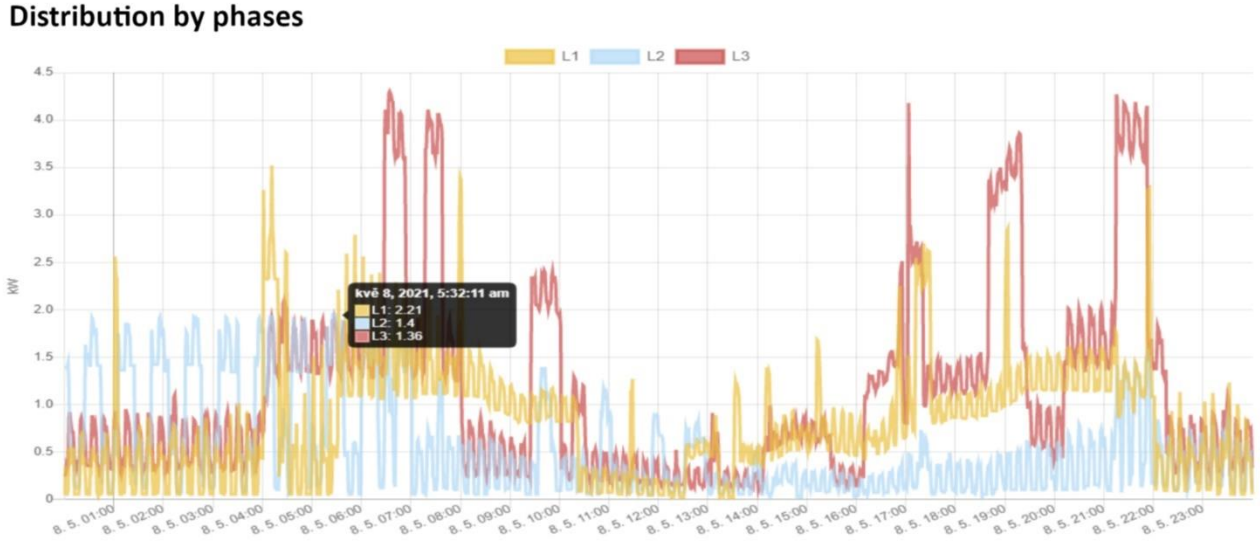
- Generation and consumption – graph comparing generation and consumption from DN.



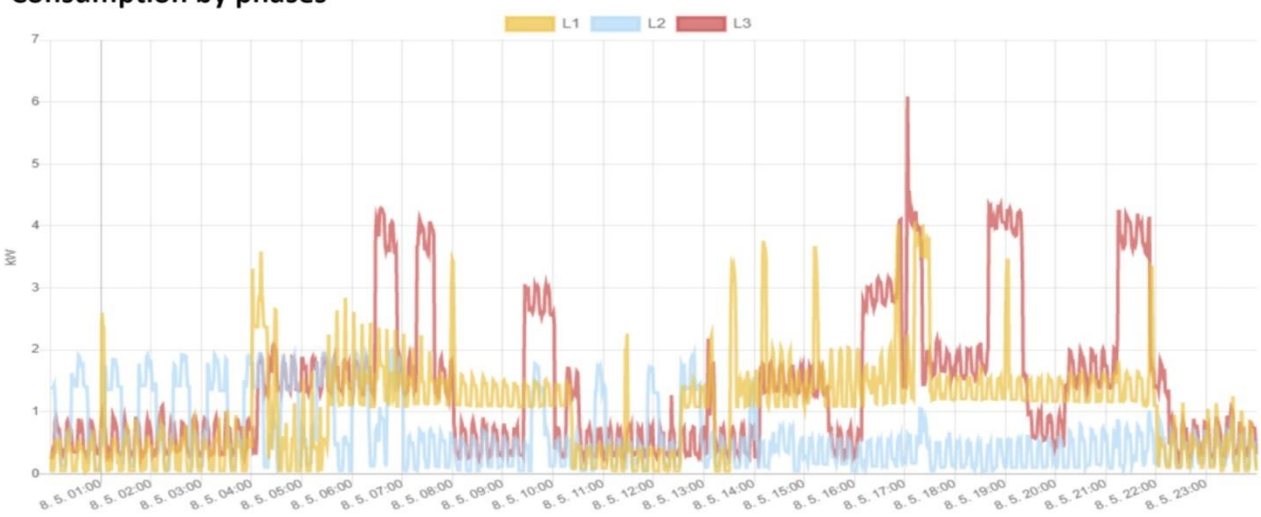
- State of charge (SOC) – graph of the instantaneous charge level of the station battery.



- Distribution by phases – graph of the power [kW] load of individual phases from DN.

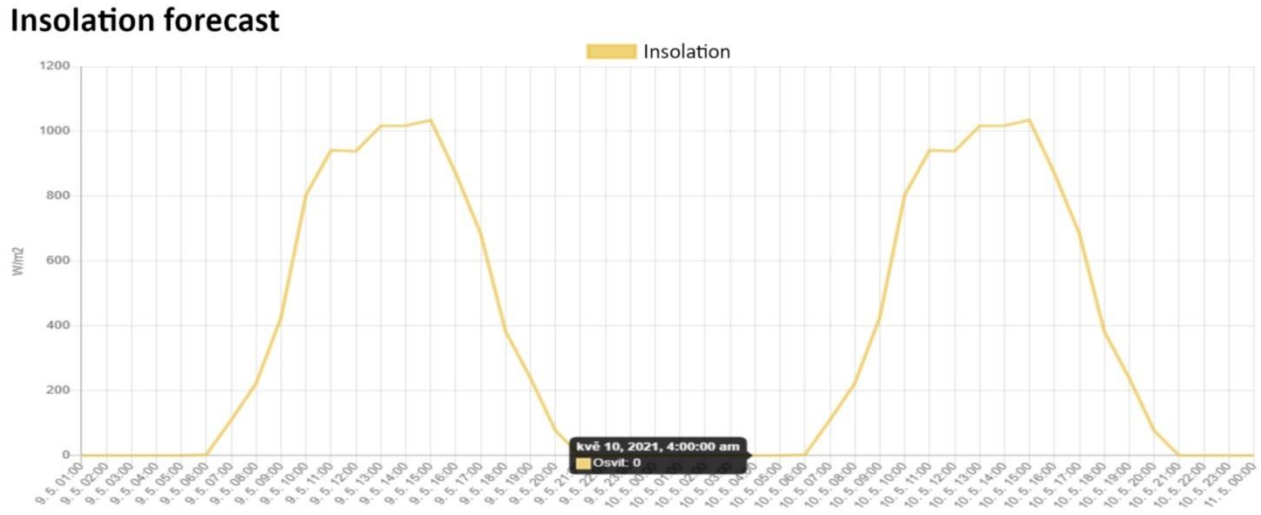


- Consumption by phases – graph of the actual power load [kW] of each phase in the household.



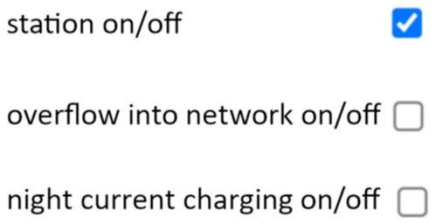
5.2.4. Diagnostic interface – Insolation forecast

On the "**PV Forecast"** page, an insolation forecast issued for the area of the operator by the Czech Hydrometeorological Institute is available to the user 24 hours in advance. The forecast data is downloaded automatically. The station can be configured to control the level of battery usage according to the expected forecast.



5.2.5. Control interface – Controls

On the "**Controls**" page, all the necessary controls for controlling and adjusting the operation of the station are available to the user. The basic controls include:

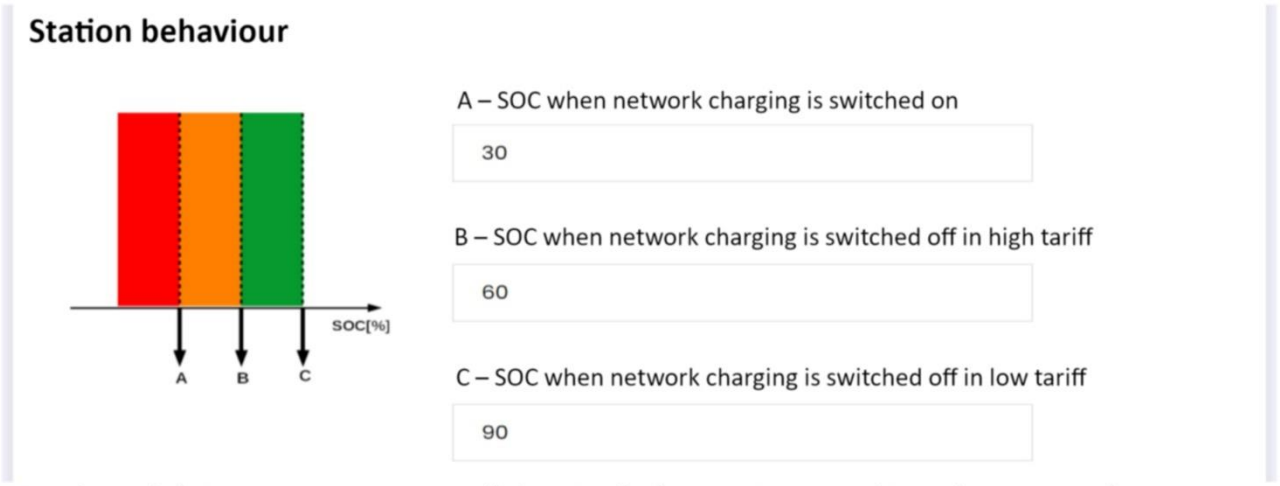


Mode selection by checking or unchecking it in the appropriate place. Mode activation is set by checking the checkbox!

!WARNING! - EVERY SELECTION OR CHANGE MUST BE CONFIRMED AFTER SETTING BY CLICKING ON THE **SAVE** GREEN BOX AT THE BOTTOM OF THE "**Controls**" PAGE.

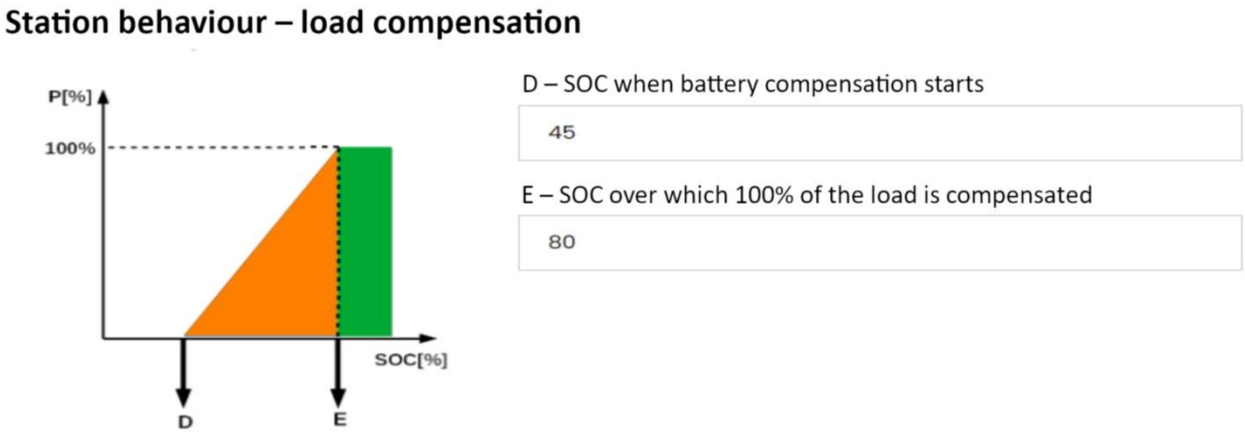
Setting the station behaviour is done by entering the percentage value of the SOC battery charge level for each control level. The setting is performed by writing the desired value. The system and application have built-in protection against entering values that can cause damage to the batteries or the station.

Grid charging is a tool to protect the batteries in the event of poor insolation, for example in winter months when the cells may be undercharged due to the station's own internal consumption. It is at the discretion of the user and the equipment supplier what settings to choose with respect to the operator's contractual terms with the distribution company.

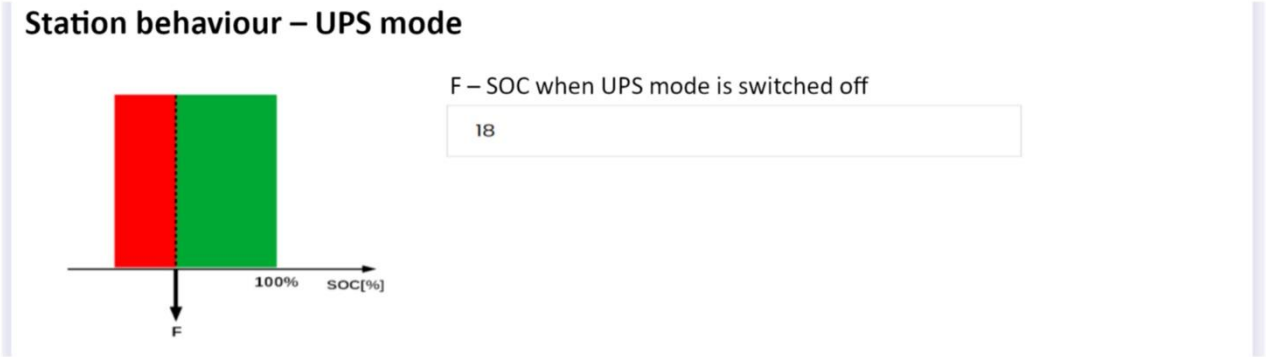


The actual behaviour of the station with respect to the instantaneous generation value and the battery state of charge is set in the field "**Station behaviour – Load compensation**". By setting parameters D and E (see the diagram below), the station is set to deliver power from 0% of the inverter power capability to 100% of the inverter power capability, including short-term overloads. When the charge level drops below D, the station enters the network monitoring mode in the UPS mode. In the event of a network failure, it will switch to the ISLAND mode. The station then waits for the possibility of recharging the battery from the solar source or, if enabled, charging from the grid according to the settings, see above.

In the case of a charge level above the value E, the station power inverter operates in the full power range.



UPS mode limitation is set by parameter F, which monitors battery undercharge and sets the station to the Deep-Sleep mode.



In order for the station to perform the functions of phase overload compensation, it is necessary to enter the value of the main circuit breaker before the meter. The station then supplies increased unbalanced power to the higher load phases.

5.2.6. Control interface – Data

Data outputs in CSV format are prepared for the user, which can be downloaded for further processing and personal archiving.