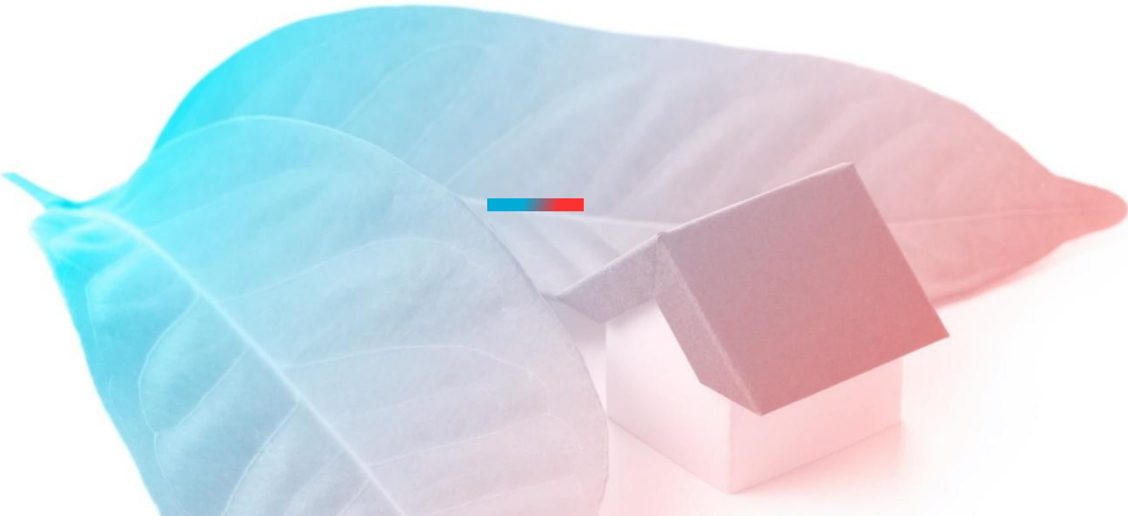
Deliverable 3.9
Installation strategies of the electrical storage system



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Note: This document includes installation strategies for the Electrical Storage System that can be applied to a generic location and implementation. It considers the design performed for the related demos sites (Thessaloniki, Sopron, Cork and Santiago (USC)), as well as the feedback from implementations completed in Thessaloniki and Santiago demo sites. The installation process in the other related demo sites (Sopron and Cork) are still on going as of 15th December 2024; therefore, this deliverable will be updated once the installation and commissioning process finishes in these demo sites to consider the corresponding feedback.

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D3.9 Installation strategies of the electrical storage system.

Summary			
This deliverable was prepared in the context of Task 3.5 "Engineering, installation strategies and prototyping for electrical storage"; previously to this deliverable it was prepared the D3.8 related to the "Design of the Electrical Storage System" as part of the same task. The present D3.9 is focused on the installation strategies of the Electrical Storage System (ESS) that use Li-ion battery modules, with LFP technology, compatible with hybrid inverters. These strategies can be applied in implementations, where the MiniStor system will be installed; they consider the design performed for the related demo sites (Thessaloniki, Sopron, Cork and Santiago (USC)), as well as the feedback from these demonstration sites. The strategies include the initial works for ESS installation, the electrical connection strategies, the communication connection strategies, the regulation strategies for the ESS and complementary information required for the installation process.			
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Abbreviations and acronyms

AC	Alternating Current
API	Application Programming Interface
CTs	Current transformers
DC	Direct Current
BMU	Battery Management Unit
ESS	Electrical Storage System
FPC	Flat Plate Collectors
IP	Ingress Protection
LFP	Lithium-Iron-Phosphate
MPPT	Maxim Power Point Tracker
PCM	Phase Change Materials
PLC	Programmable logic controller
PV	Photovoltaic
PVT	Photovoltaic-Thermal
RES	Renewable Energy Sources
SOC	State Of Charge
TCM	Thermochemical

1 Introduction

MiniStor[1] is a project funded by the European Union's Horizon 2020 research and innovation programme, focused on the design and production of an innovative compact integrated thermal storage system to implement sustainable energy storage for heating, cooling and electricity, adaptable to existing systems in residential buildings. The MiniStor storage system is based on a thermochemical (TCM) material reaction, combined with PCM (phase-change materials), and complemented by an electrical storage system (ESS). The MiniStor system can use different Renewable Energy Sources (RES), such as hybrid photovoltaic-thermal (PVT) collectors.

The MiniStor Project includes five demonstration facilities located in Greece, Hungary, Ireland and Spain: four of them equipped with PVT collectors as RES technologies. These PVT collectors can produce both electricity and thermal energy in the same unit, achieving better overall energy efficiency compared to normal photovoltaic (PV) panels. To store and manage the electricity production from the PVT collectors, each implementation also includes an Electrical Storage Systems (ESS) based on Li-ion technology.

This deliverable presents the "Installation Strategies of the Electrical Storage System", prepared in the context of Task 3.5. Prior to this deliverable, deliverable D3.8, related to the "Design of the Electrical Storage System", was presented and approved as part of the same task.

The present deliverable is focused on the ESS installation strategies which can be applied in a generic location where the MiniStor system will be installed. These strategies consider the design performed for the related demo sites in Thessaloniki (Greece), Sopron (Hungary), Cork (Ireland) and Santiago de Compostela (Spain)[2], as well as the feedback from the implementations in those demo sites.

2 Electrical PVT system concept

The general scheme of the electrical PVT generation system is shown in Figure 1, which consists of the PVT solar field and the ESS. The main components of the ESS are the hybrid inverter, the electrical batteries based on Li-ion technology, the PVT panels and the electrical smart meter.

The inverter is one of the core elements in any PV installation, as it converts the direct current electricity (DC) produced by the solar PV panels into alternating current electricity (AC), ready to be used. In the PVT system, the inverter performs the same function, specifically for the electrical part of the system.

The DC electricity produced by the PVT solar field is fed through the DC electrical lines into the inverter; after the DC/AC conversion inside the inverter, the AC electricity produced is fed into the main electrical panel in the home or building using a dedicated AC electrical line. Additionally, a bidirectional smart electrical meter must be installed in the connection line to the external electrical grid (main grid), following local regulation and requirements.

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[1] *Minimal Size Thermal and Electrical Energy Storage System for In-Situ Residential Installation*

[2] *The demonstration sites in Kimmeria (Greece) does not incorporate PVT collectors and the ESS designed in the context of Task 3.5. This site already has other local RES (solar thermal energy and biomass).*

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The inverter selected for the ESS in the MiniStor project is a hybrid type, which fulfils a dual function: the conversion of current from DC to AC as well as to control the charging and discharging processes of the electrical batteries. Thus, the hybrid inverter is the smart element in the overall system, managing the different operating modes.

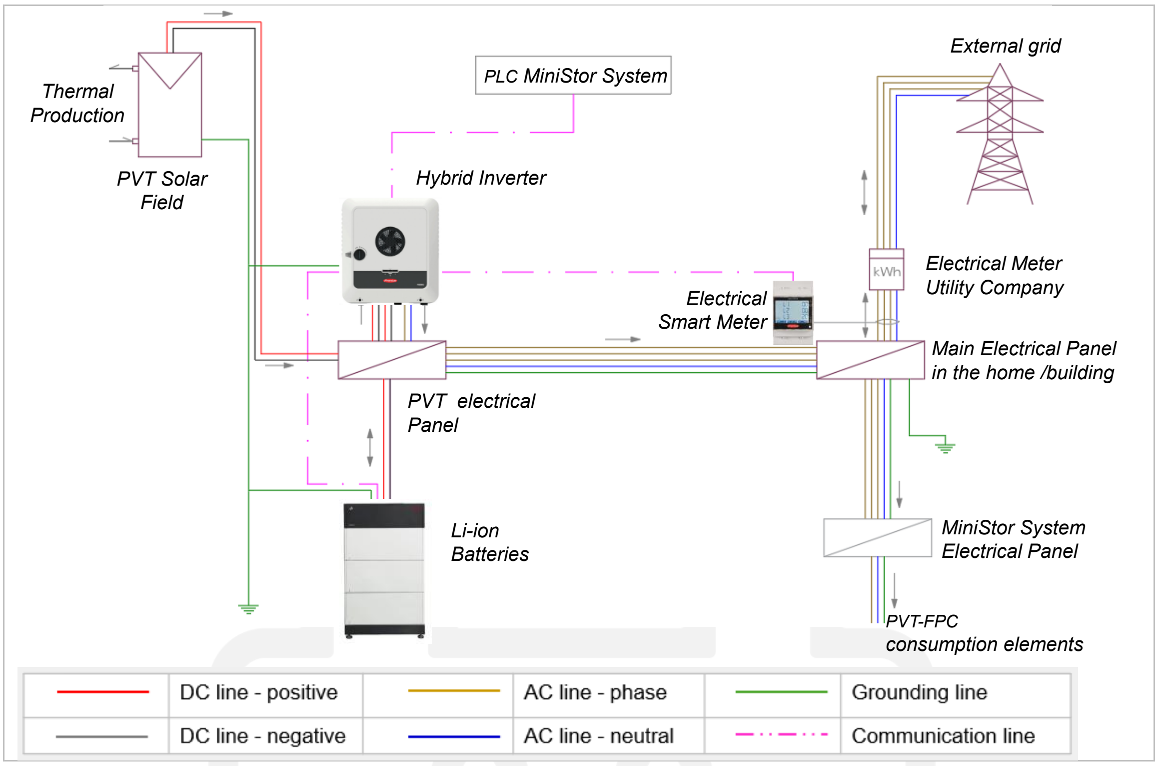


Figure 1: Base concept of the electrical PVT system

The hybrid inverter continuously collects information from the electrical smart meter about the electricity sent or taken from the external grid, along with information about the state of charge (SOC) in the Li-ion Batteries. Using this information, it defines the operating mode in the ESS, which mainly includes:

(1) direct use of the electricity produced by the electrical receptors in the home or building (and also in the MiniStor system),
(2) charging the electrical batteries using the surplus of electrical production or, when allowed, using grid electricity during low-price periods,
(3) discharging the electrical batteries to meet the electricity demand, or
(4) feeding the surplus of electrical production into the grid according to the existing regulatory conditions in the demo site (e.g. compensation prices, net balance).

Apart from the electrical connection, communication between the inverter and the MiniStor PLC is one of the relevant aspects of the ESS. The selected hybrid inverter includes a Modbus connection, enabling the monitoring of various electrical variables such as voltage, current, frequency, SOC, operation temperature and others, aside from the ability to set different operation modes in the system.

The hydraulic elements in the PVT thermal system also have minor electrical receptors, including a solar circulation pump, a solar air cooler, and a solar controller, identified in Figure 1 as PVT-FPC consumption elements. To power these elements, the electrical panel included in the MiniStor system has three pre-assembled electrical circuits.

The following section presents the installation and connection issues applied to the ESS in the context of the MiniStor project, including: (1) a summary of the equipment linked to the ESS, already selected in D3.8[3], (2) location and safety considerations (section 4), and (3) the installation strategies (section 5), which include initial works considerations, electrical connection strategies, communication connection strategies, regulation strategies, and general information about APIs to be used in the installation process.

Finally, section 0 summarizes the main installation strategies applied in demonstration sites related to the present deliverable. The installation and commissioning results will be presented in detail in deliverables D6.3 *"Results from Pre-pilot Implementation and Stakeholder Training"* and D6.4 "*Installation and Commissioning report for all the MiniStor Demo Sites*", both prepared in the context of WP6.

3 ESS size and equipment selection

The design, sizing and selection of components of the ESS were carried out in the context of Task 3.5, with the corresponding results included in the D3.8, *"Design of the Electrical Storage System"*. For sizing the battery capacity, a simplified simulation model was implemented in the dynamic simulation program TRNSYS, considering the electrical production of the PVT solar field, as well as the electrical consumption profiles for the building and the MiniStor system.

The inverter and batteries, the main components of the ESS, were defined based on the electrical characteristics of the PVT collectors, the peak power of the PVT solar field, and the storage battery capacity obtained from the simulations. Table 1 summarizes the equipment selected for the demonstration sites, that includes PVT solar field and ESS in the implementations.

Table 1: Summary of ESS equipment specified for the demonstration sites

Demo Site		Peak Power PVT solar field	Hybrid Inverter Model	Li-ion Battery Model
1.	Thessaloniki	2.65 kW	Fronius, Symo GEN24 Plus 3.0 3 phase, 3.0 kW AC	BYD, HVS 7.7, 7.68 kWh
2.	Sopron	2.12 kW - New 7.9 kW (Existing PV)	Huawei, SUN2000-8 KTL-M1 3 phase, 8.0 kW AC (Existing Inverter)	Luna, LUNA2000-10-S0, 10 kWh
3.	Cork	1.06 kW	Fronius, Primo GEN24 Plus 3.0 1 phase, 3.0 kW AC	BYD, HVS 5.1, 5.1 kWh
4.	Santiago (USC)	8 kW	Fronius, Symo GEN24 Plus 8.0 3 phase, 3.0 kW AC	BYD, HVM 16.6, 16.56 kWh

As indicated in deliverable D3.8, the specified inverters were of the hybrid type, selected for their higher system efficiency due to the DC high-voltage connection with the batteries. Regarding the batteries, the specified models were Li-ion type with LFP (Lithium-Iron-Phosphate) chemistry, which offers the highest performance in terms of safety compared to other options available on the market.

Specifically, the HVS and HVM battery models, manufactured by BYD Co. Ltd, were selected due to their wider range of compatible inverter brands. For the inverters, the hybrid models manufactured by Fronius International Gmbh were chosen because they met the project

[3] *D3.8: Design of the electrical storage system*

requirements in terms of connectivity and control via Modbus. Details about the selected equipment are presented in the aforementioned deliverable.

In the case of the Sopron demo site, the equipment specifications were reviewed during 2023, in the context of implementation tasks performed in WP6, as the site had installed a new PV system in 2022. This installation includes a PV solar field of 7.9 kWp, and a Hybrid inverter 8 kW in AC, manufactured by Huawei Technologies Co., Ltd. Consequently, the final battery selected was a model compatible with the existing inverter, while maintaining the base specifications indicated in D3.8 for this demonstration site.

4 ESS location and safety considerations

The ESS must be located according to the manufacturer's requirements. Currently, there are several brands designed to be used in buildings and homes. In general, ESS manufacturers indicate the following requirements and recommendations for the Li-ion batteries location:

- The altitude of the ESS location should be below 3000 m.
- The ambient temperature must remain within a range specified by the manufacturer (approximately -10 °C and +50 °C).
- The ambient humidity should be between 5 and 95%.
- The ESS must be placed in a site without direct exposure to the solar rays.
- The location of the ESS and any auxiliar elements must be inaccessible to children.
- The installation site must not be near any fire sources.
- The ESS must be installed on a solid support surface, taking into account their weight and dimensions.

Following these recommendations, two basic locations strategies were adopted in MiniStor project: i) installation outside the building, next to the MiniStor system, ii) installation inside the building in a safe zone. Table 2 summarizes the specific actions adopted to fulfil the location requirements for the two mentioned strategies:

Table 2: General location strategies of the ESS and base recommendations

General location strategy		Main considerations for the location strategy
1.	Inside the buildings	- Location strategy used in climatic zones with severe weather conditions. - Placement in an interior safe zone, inaccessible to children (in homes) or to the public (in commercial buildings). - Need of air conditioning equipment, due to severe weather conditions, to operate within the ambient temperature range required by the batteries.
2.	Outside the building	- Location strategy used in climatic zones with moderate weather conditions. - Placement next to the MiniStor system to optimize the overall space used by the systems. - Use of front/lateral films to block direct sunlight.

When the equipment is installed outdoors, the degrees of protection (IP) provided by enclosures must be verified. These IP ratings are regulated according to the EN 60529:2018 standard; in general, only components with an IP54 rating or higher may be installed outdoors. The inverters and batteries specified for the MiniStor project are suitable for outdoor installation, as they have the following IP ratings:

- Fronius inverter, Gen 24 Plus models: IP66
- Batteries BYD. HVS and HVM models: IP55

- Batteries Huawei, Luna models IP66

Despite the adequate degree of protection of the equipment, it must not be exposed to direct sunlight or rain, as shown in Figure 2. Additionally, the ambient temperature must not exceed 50 °C for BYD and 55 °C for Huawei batteries.

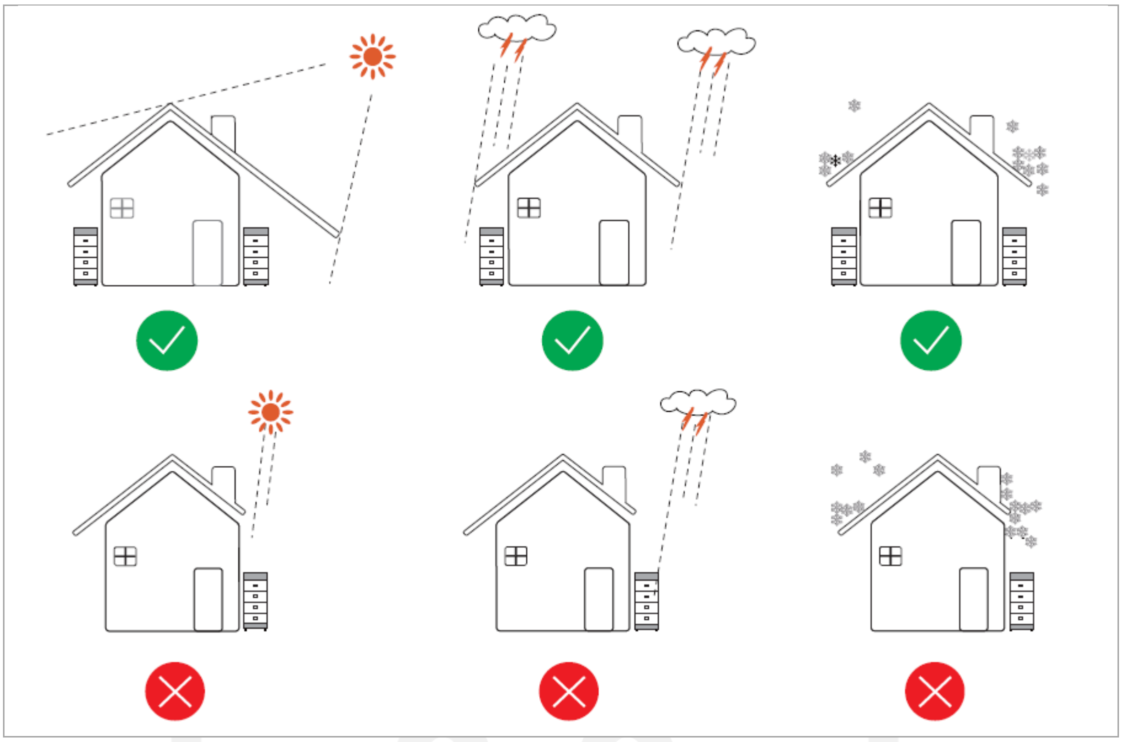


Figure 2: Suitable location of ESS for outdoors installation strategy
Source: BYD Co. Ltd

In addition to adopting a safe strategic location, the system incorporates other internal and external safety elements, following the EN IEC 62485-5:2021/AC:2022-07 standard. The main safety requirements are:

- Electrical protection in the interconnection line between the hybrid inverter and the batteries. The electrical battery models selected for the MiniStor project include this protection internally, together with the Battery Management Unit.
- A ground line, which must be connected to the general ground building connection.
- Installation of fire extinguishers according to local regulations and manufacturer recommendations. Several manufacturers recommend installing ABC or carbon dioxide extinguisher near the ESS location, as water must not be used for extinguishing those fires.

5 Installation strategies for the ESS

5.1 Initial works

The initial work of ESS installation starts with the storage of the batteries on-site, as well as the preparation of materials needed for the electrical connection. Regarding the storage of Li-ion battery modules, each brand has its own specifications that must be consulted in the corresponding manual. Usually, the main recommendations from manufacturers are:

- Protect battery modules during the transport and handle tasks with suitable packaging.
- Transport and store battery modules at ambient temperatures below the maximum temperature value (50 °C approx.), avoiding direct exposure to sunlight or storage in highly humid environments.
- Ensure battery modules are not in contact with substances such as oxidizers, water, cleaning solvents, etc.
- Avoid subjecting battery modules to shocks, impacts, etc. In case the battery modules are cracked, broken or similar, they must not be installed, and the manufacturer should be contacted.
- Any repairs to battery modules must be carried out directly by the manufacturer.

Prior to installing and connecting the battery modules, all necessary materials must also be prepared, including, but not limited to the following:

- Review the maximum distance allowed between the hybrid inverters and the battery modules.
- Install the required electrical protection for the electrical line between the inverter and the Li-ion batteries.
- Prepare the electrical cables, communication cables, and corresponding conduits.
- Prepare the connection elements required for the ESS equipment (inverter, battery modules), following the corresponding manufacturer's manuals.
- Install the ground connections up to the PVT electrical panel and the ESS.

5.2 General electrical connection strategies

The connection between ESS components and the PVT electrical system can be implemented following three main connection strategies:

1) Coupling to AC voltage using a charger-inverter to manage the charging/discharging process in the batteries and another independent inverter to convert the DC current provided by PVT panels into AC current.
2) Coupling to low DC voltage using a hybrid inverter.
3) Coupling to high DC voltage using also a hybrid inverter.

Table 3 summarizes the main advantages and disadvantages of these electrical ESS connection strategies.

Table 3: General Electrical ESS connection strategies with main advantages and disadvantages

Electrical connection strategy		Advantages	Disadvantages
1.	ESS coupled in AC	- Compatible with any PV and PVT system due to the use of an independent inverter-charger to connect the ESS. - Use of low-voltage battery modules, usually up to 48 V, with a wide range of brands available. - Lower cost of battery modules due to the wide range of brands available in the market.	- The system requires more space for installing the inverter-charger coupled to the ESS, as well as the inverter for the PV or PVT system. - Highest losses due to the use of various conversion processes and an additional inverter. - Requires higher current capacity for the electrical connection cables due to the lower voltage of the battery modules.
2.	ESS coupled in low DC voltage.	- The system usually requires only a hybrid inverter, without an additional inverter-charger for the ESS. - Lower space required for the inverter equipment. - Higher efficiency thanks to fewer electrical conversion processes.	- Restriction in the power capacity of hybrid inverters, currently limited to less than 20 kW in AC, and limitations on coupling with non-hybrid inverters. - Costly battery modules and the need for compatibility between battery modules and the hybrid inverters. - Requires higher current capacity electrical connection cables, due to the lower voltage of the battery modules.
3.	ESS coupled in high DC voltage	- The system usually requires only a hybrid inverter, without an additional inverter-charger for the ESS. - Lower space required for the inverter equipment. - Higher efficiency thanks to fewer electrical conversion processes and higher voltage connection. - Lower current capacity required for electrical cables due to the higher voltage connection.	- Restriction in the power capacity of hybrid inverters, currently limited to less than 20 kW in AC, and limitations on coupling with non-hybrid inverters. - Costly battery modules and the need for compatibility between battery modules and the hybrid inverters.

The connection strategy selected for the ESS in the MiniStor was the strategy number 3, in which the ESS is connected to a hybrid inverter using high DC voltage. This option was selected considering the inverter size required at the demonstration sites and the advantages in terms of efficiency indicated in Table 3.

5.3 Electrical connection of ESS

5.3.1 Connection of the hybrid inverter

As indicated in section 2, the hybrid inverter is the heart of the ESS, as the main components of the system must be connected to it, including the strings from the PVT solar field, the battery towers (to be installed next to the inverter), and the smart meter, located in the main electrical panel of the home or building.

Each manufacturer designs its own connection system for its inverter models; therefore, the installation of this component must be carried out following the corresponding installation manual. Figure 3 shows the connection terminal block, corresponding to the type of hybrid inverter used in three of the demonstration sites of the MiniStor project (Fronius Gen 24 Plus).

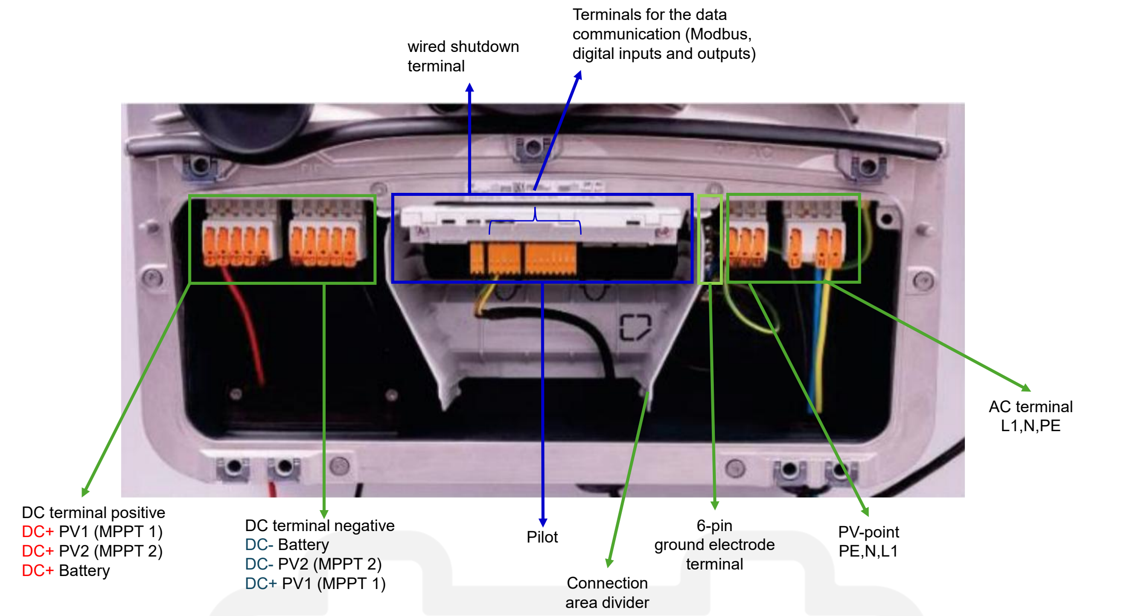


Figure 3: Connection terminal block, on the hybrid inverter, Fronius, model Gen 24 Plus, three-phase

Source: Fronius International GmbH

The Figure 3 shows the connection terminals for two strings of photovoltaic panels (PV1 and PV2), located on the left side of the terminal block. In this inverter model, each string has an independent maximum power point tracker (MPPT1 and MPPT2). The DC terminals for the connection of the battery tower (DC+ Battery and DC- Battery) are also located on the left side.

On the other hand, the AC connection terminals are located on the right side of the terminal block, including the terminals for the phases (L1/L2/L3), the neutral line (N) and the protection line (PE).

Finally, the central area contains the terminals for connecting the data cables for communication with: i) the smart meter, ii) the batteries and iii) the connection to the Internet and communication via Modbus with the PLC of the MiniStor System.

The overall connection process must carefully follow the procedures indicated by the product manufacturers in their respective installation manuals.

5.3.2 Connection between the inverter and the batteries

The Li-ion batteries selected for the implementations in the MiniStor project are arranged in individual towers, as shown in Figure 4, which includes a Battery Management Unit (BMU), located at the top part, several battery modules and a base to support the components. These components are supplied separately, so the assembly procedure must follow the manufacturer's instructions.

The BMU manages the Li-ion battery modules under safe operation rules and communicates with the hybrid inverter for monitoring and regulating sensitive variables in the Li-ion batteries, such as the state of charge (SOC) and operating temperature.

The electrical connection between the inverter and the battery tower must be performed in accordance with the manufacturers' installation manual. Figure 4 illustrates the basic connection between a BYD battery tower (HVS and HVM models), and a compatible inverter, in this case a Fronius inverter model Gen24 Plus. Both the inverter and the battery tower are designed to be installed next to each other.

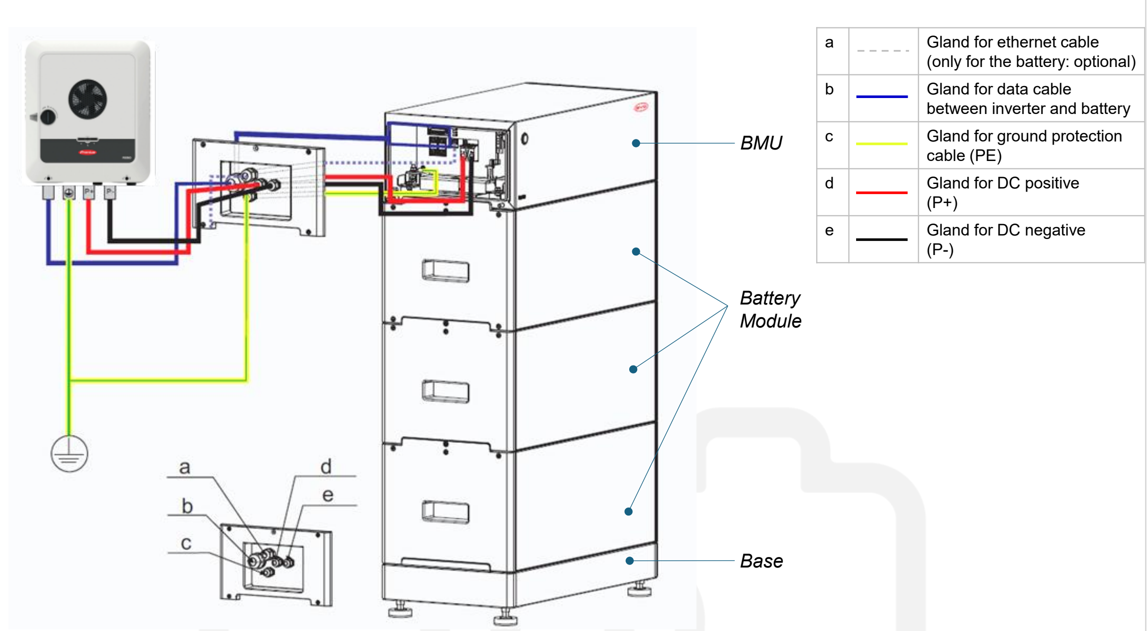


Figure 4: Connection between an inverter Fronius, model Gen 24 plus and a battery tower, models BYD HVS/ HVM Source: *Adapted from BYD Co. Ltd*

This electrical connection includes the positive DC cable (red line), the negative DC cable (black line) and the ground protection cable (yellow line), all made of copper and properly insulated. The diameter of the DC cables must be calculated considering the charge/discharge current of the battery tower, as specified in the corresponding product datasheet.

The power line between the inverter and the batteries must include the necessary electrical protection elements. In the case of BYD HVS and HVM models, the battery tower already incorporates these electrical protections for overloads, short circuits and ground current leakage, thereby reducing installation time.

In addition to the electrical connections, a communication cable must be installed between the inverter and the battery tower (blue line). This cable must be UTP type, category 5 or higher, as indicated in section 5.4. Each inverter manufacturer specifies the connection details in its inverter terminal block documentation.

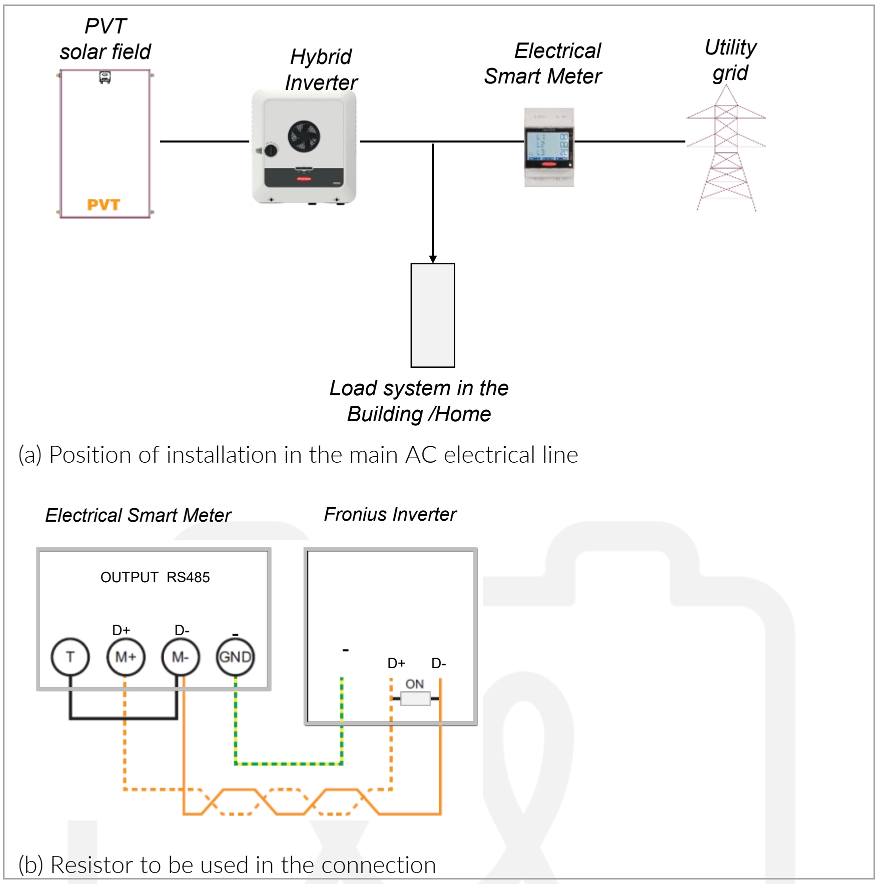
5.3.3 Connection of the smart meter

The electrical smart meter is a fundamental component for the operation of the ESS, as it provides real-time information about the electricity sent or taken from the external electrical

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869821

grid. Using this information, the hybrid inverter determines if there is surplus electrical production from the PVT collectors and manages the storage of electricity in the batteries.

This component is installed either inside the main electrical panel of the house or building, or in an electrical panel located next to the main panel. The electrical connection can be made indirectly or directly, depending on whether current transformers (CTs) are required.



(a) Position of installation in the main AC electrical line

(b) Resistor to be used in the connection

Figure 5: Electrical smart meter-details for installation and connection

Source: Adapted from Fronius

In the case of the Fronius inverters selected for the MiniStor project, the type of electrical meter used is direct connection. The component must be installed according to the manufacturer's installation manual. In general, the installation recommendations are as follows:

- The electrical smart meter must be installed at the feed point in the electrical grid, as illustrated in Figure 5.a.
- This component requires an electrical circuit breaker for overload and overcurrent protection.
- The communication cable between the Inverter and the electrical smart meter should be connected to the inverter using a terminating resistor to avoid interference (Figure 5.b). Additionally, the cable must meet the minimal specifications indicated in section 5.4.

5.4 Communication connections

To operate the system, it is necessary to establish communication between the hybrid inverter and the BMU (in the battery tower) and the electrical smart meter, as well as to allow the communication between the hybrid inverter and the MiniStor PLC.

The hybrid inverter includes an integrated data logger and a web server. In general, connection to third-party components is provided through interfaces such as Modbus TCP SunSpec, Modbus RTU SunSpec or Fronius Solar API (JSON). Modbus SunSpec is an open Modbus-based communication protocol aligned with the SunSpec Alliance standard.

The inverter connects to the platform using Modbus TCP/IP protocol via Ethernet, either by cable or WLAN, and through the PLC incorporated in the MiniStor system. The inverter also supports the Modbus RTU interface (via RS-485) to connect with the battery and the electrical smart meter. The battery system is equipped with WLAN interface, and it is recommended to connect it to the Internet for diagnostic purposes and firmware updates.

Regarding wiring, the length and quality of the communication cables affects the quality of the signal, so specific requirements must be met. The cable category for both RS485 protocol and network connection should be Cat5, Cat5e or higher, and it must be shielded. The cable should be a straight-through wire cable, UV resistant (for of outdoor use), with a maximum length of 10 m. The plug type must be metal-shielded RJ45 of Cat5, Cat5e or higher.

The communication between the inverter and the MiniStor PLC is established using the Modbus TCP/IP protocol. This protocol enables reliable data exchange over an Ethernet network, allowing the MiniStor PLC to monitor and control the inverter parameters in real-time. The key variables involved are included in Table 4:

Table 4: Main variables integrated in MiniStor PLC

Variable Description	Key	Unit	Register
Phase A Current	AphA	A	40072
Phase B Current	AphB	A	40073
Phase C Current	AphC	A	40074
Phase Voltage AB	PPVphAB	V	40076
Phase Voltage BC	PPVphBC	V	40077
Phase Voltage CA	PPVphCA	V	40078
Phase Voltage AN	PhVphA	V	40079
Phase Voltage BN	PhVphB	V	40080
Phase Voltage CN	PhVphC	V	40081
AC Power	genW	W	40083
AC Apparent Power	genVA	VA	40087
AC Reactive Power	genVAr	Var	40089
AC Power Factor	genPF	-	40091
Cabinet Temperature	TmpCab	°C	40102

DC Current	module1DCA	A	40272
DC Voltage	module1DCV	V	40273
DC Power	module1DCW	W	40274
DC Current	module2DCA	A	40292
DC Voltage	module2DCV	V	40293
DC Power	module2DCW	W	40294
Setpoint for maximum charge	WChaMax	W	40345
Currently available energy as a percentage of the capacity rating.	ChaState	-	40351
State of charge ChaState minus storage reserve MinRsvPct times capacity rating AhrRtg.	StorAval	-	40352

The inverter and MiniStor PLC are connected via an Ethernet interface. The PLC acts as the Modbus Client, sending requests to the inverter, which functions as the Server. This setup facilitates the exchange of operational data and control commands. A visual representation of the communication setup is included next (Figure 6):

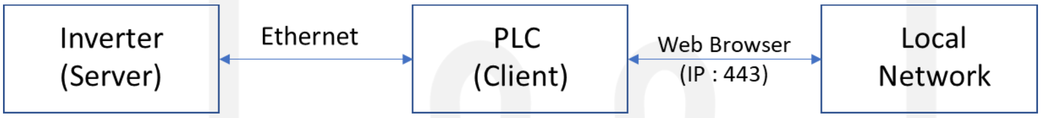


Figure 6: Communication setup for the inverter and MiniStor PLC

The Modbus integration between the inverter and the MiniStor PLC is carried out by initially configuring the inverter to operate as a Modbus server. This involves assigning an IP address, specifying a communication port (typically port 502 for Modbus TCP/IP), and defining the Modbus registers that contain the desired data points, such as power, voltage, and frequency.

The MiniStor PLC, on the other hand, is configured as a Modbus client. At this stage, the connection is established by specifying the IP address and port of the inverter, and the inverter's Modbus registers are mapped to the corresponding variables in the PLC. Finally, communication is validated using diagnostic tools such as Node-RED, to read real-time values and ensure the integration functions correctly.

Further technical specifications, including a complete list of Modbus registers, scaling factors, and validation procedures, will be provided in the related deliverables of WP5.

5.5 Regulation strategies for the ESS

The regulation strategies for the ESS take into account different interaction options between the Li-ion batteries, the hybrid inverter and the grid, considering the specific legal restrictions in the demo sites countries regarding local energy production and the grid. Based on this, the MiniStor project has identified the following four types of regulations (see deliverable D3.8), as represented in Figure 7.

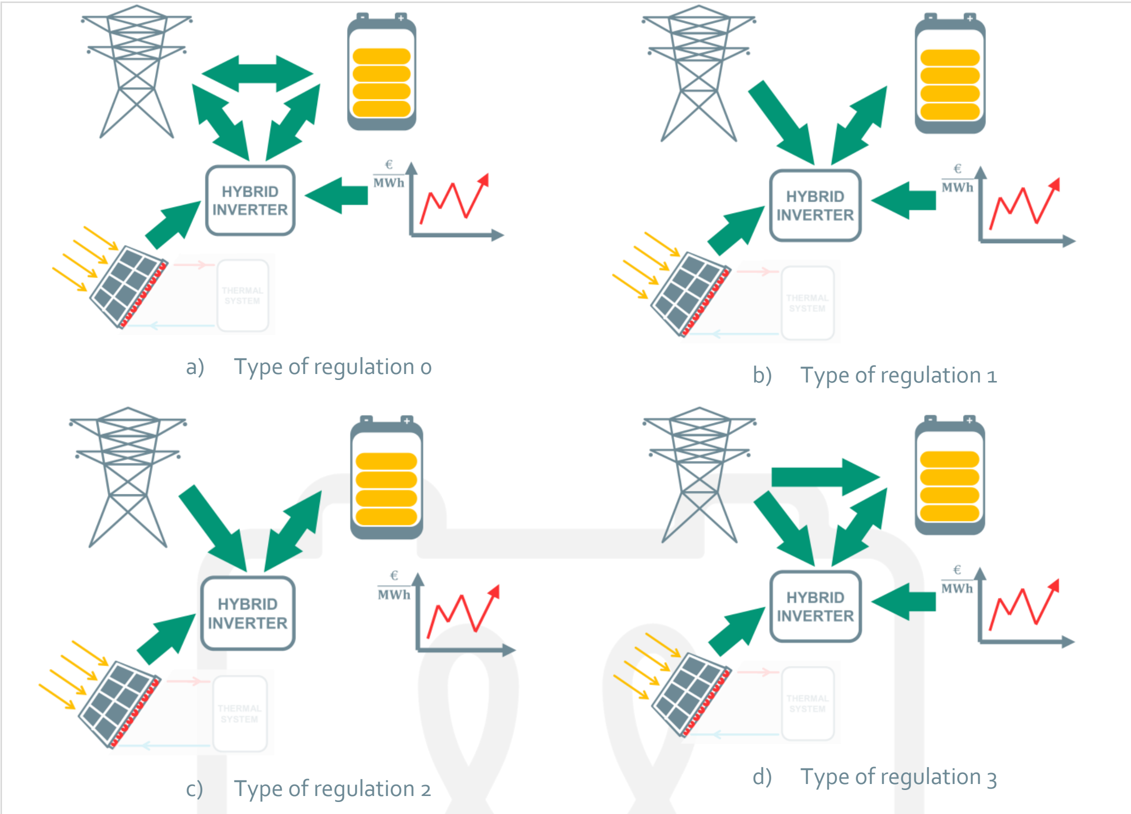


Figure 7: Regulation strategies for the ESS

- Type 0: Interaction between ESS and the grid for charging the Li-Ion batteries or feeding electricity into the grid is allowed depending on the price signal (Figure 7.a).
- Type 1: Interaction between ESS and the grid for charging the Li-Ion batteries or feeding electricity into the grid is not allowed, but the price signal is used to know when electrical consumption either from batteries and PVT or from grid is prioritized (Figure 7.b).
- Type 2: Interaction between ESS and the grid for charging the Li-Ion batteries or feeding electricity into the grid is not allowed, nor is the price signal considered. The energy coming from batteries is always prioritized for its use to cover the demand. Otherwise, the energy needs are covered by the main grid (Figure 7.c).
- Type 3: Interaction between ESS and the grid for charging the Li-Ion batteries is allowed but feeding electricity into the grid is forbidden. Price signal is used to know when to prioritize electrical consumption from batteries and PVT or from grid (Figure 7.d).

As stated previously and represented in Figure 7, Type 2 is the simplest in terms of interaction between the ESS and the main grid, while Type 0 is the most complex and dynamic. Considering the legal context in the MiniStor implementations, Regulation Type 1 was applied in the MiniStor demonstration sites.

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5.6 APPs to be used in the installation process

To properly complete the installation and commissioning process, it is necessary to use the different software applications (APPs) and tools provided by the equipment manufacturers. These applications enable the configuration process. Table 5 summarizes the applications required by the inverters and battery models specified for the MiniStor implementations.

Table 5: APPs to be used in the installation process

Electrical Subsystem		Equipment	Applications
1.	Fronius	- Inverters model Gen 24	- Fronius Solar Start - Fronius Solar Web
2.	BYD	- Batteries HVS and HVM models	- BYD Be Connect
3	Huawei	- Inverters Sun2000 models - Battery Luna models	- Huawei Fusion Solar

6 Summary of installations strategies applied in the pilot implementations

The ESS implementations have been carried out at four of the five MiniStor project demonstration sites: i) Thessaloniki (Greece); ii) Santiago de Compostela (Spain); iii) Cork (Ireland) and iv) Sopron (Hungary).

Commissioning slides were prepared for all the demo sites. Those commissioning slides were intended to summarize and explain the procedure before and during the commissioning itself. Those slides were reviewed and updated according to the feedback received from the demos and have been a cornerstone of the installation procedures that were followed.

Table 6 summarizes the installation strategies adopted for this system for these demo sites and the feedback received, that was included in the recommendations below; while the full details about the implementations will be presented in two deliverables prepared in the context of WP6: D6.3, which covers the results from pre-pilot implementation and stakeholder training, and D6.4, linked to the installation and commissioning report for all the MiniStor demo sites.

Installation strategies recommendations:

- Install the manufacturers' APPs prior to the commissioning process.
- Ensure that technical personnel carry out the commissioning process, including the partner supplying the ESS equipment, the technical staff at the demonstration site, and a qualified electrical installer belonging to the demonstration site and/or subcontractors.
- Review if the installation and operation manuals are provided within the package delivery. If not, be sure to download the manuals digital version prior to the installation and commissioning.
- Define the IP address to be assigned to the inverter in advance to establish Modbus communication with the MiniStor PLC.
- Carefully follow the instructions provided by the manufacturer's commissioning application during the process.
- Integrate the relevant ESS variables into the MiniStor platform software beforehand to enable their reading through the PLC.
- Update the equipment firmware to the newest version prior to activating Modbus communication to Modbus TCP/IP.
- Verify the correct reading of the integrated variables using the MiniStor platform.

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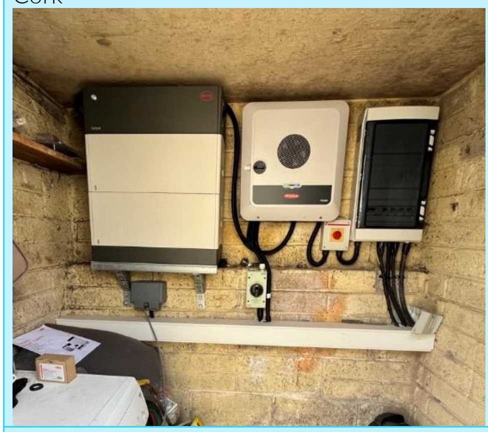
Table 6: Summary of main installation strategies applied to ESS in the implementations

Demo site	Main installations strategies applied to the ESS
Thessaloniki 	✓ Location of the ESS outdoors, next to the MiniStor system, to centralize the overall equipment location. ✓ Installation of a vertical metallic laminate to protect the battery modules and inverter from direct exposure to solar rays. ✓ Communication with the PLC of the MiniStor system via Modbus protocol. ✓ Regulation type 1.
Santiago de Compostela (USC) 	✓ Location inside the building (indoors), in a non humid zone, close to the main electrical panel of the building. ✓ Communication with the PLC of the MiniStor system via Modbus protocol ✓ Regulation type 1.
Cork 	✓ Location inside the building (indoors), in a non humid zone, close to the main electrical panel of the building. ✓ Communication with the PLC of the MiniStor system via Modbus protocol (May 2025). ✓ Recommendation: update any firmware from the inverter local access prior to setting the Modbus communication with the PLC. ✓ Regulation type 1. ✓ Review the manuals are included within the package or provide the digital versions.
Sopron	✓ Location inside the building (indoors), in a non humid zone, close to the main electrical panel of the building.

	✓ Communication with the PLC of the MiniStor system via Modbus protocol. ✓ Regulation type 1.