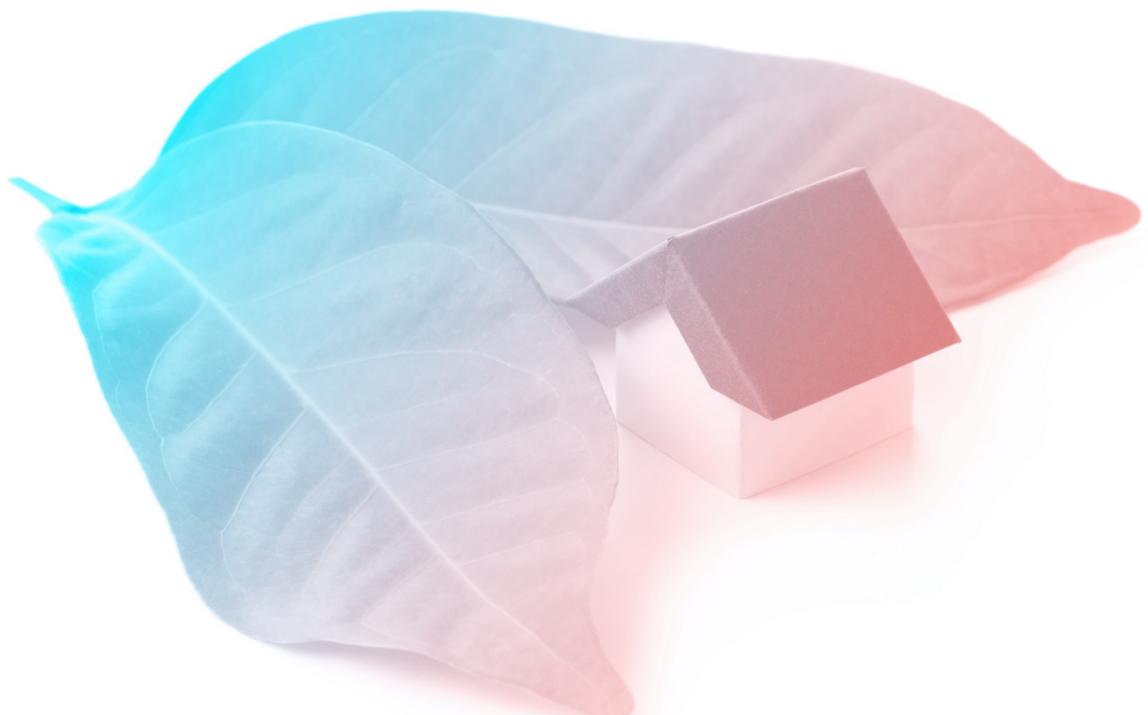




D3.3

Installation strategies of peripheral thermal equipment



Louis Schibli (HSLU), Philipp Schuetz (HSLU),
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Summary

This report presents the work conducted within the MiniStor project, focusing on the peripheral thermal components integrated into the innovative MiniStor thermal energy storage system.

The document provides a detailed overview of key peripheral elements, including the heat pump, circulation pumps, and fan coil units, emphasizing their roles, specifications, and integration within the overall system. Special attention is given to their interconnectivity and the technical interfaces that ensure efficient, reliable operation. Notably, components were pre-assembled and tested under controlled conditions at the implementation partner Psycrotherm's facilities before delivery, allowing streamlined on-site installation and commissioning.

To analyse the impressions of the demonstration site owners of the installation process, a structured feedback process captured the practical experiences and challenges faced by project partners during commissioning and operation phases. Insights from all demonstration sites, including extended laboratory testing at ÉMI, were gathered through a comprehensive questionnaire covering technical performance, installation procedures, maintenance, and operational reliability. This feedback has been instrumental in refining the system design, installation protocols, and overall project outcomes, contributing to the MiniStor system's robustness and readiness for broader market deployment.

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Index

Index.....	3
List of Images.....	4
List of Tables.....	4
1. Introduction.....	5
2. System design	6
2.1. System interconnectivity.....	8
2.1.1. Heat pump.....	8
2.1.2. Circulation pumps.....	9
2.1.3. Fan coils	10
2.2. Installation strategy	11
3. Feedback from the demonstration phase	14
3.1. Pre-pilot site in Thessaloniki.....	15
3.2. Laboratory test at ÉMI	16
3.3. Demonstration site in Kimmeria (DUTH)	17
3.4. Demonstration site in Santiago de Compostela (USC).....	18
3.5. Demonstration site in Sopron.....	20
3.6. Demonstration site in Cork.....	21



List of Images

Figure 1: Schematic representation of all thermal components of the MiniStor system and their hydraulic connections.....	6
Figure 2: The piping and instrumentation diagram (P&ID) of all thermal components of the MiniStor system.	7
Figure 3: Schematic representation of the heat pump and its connected systems.....	8
Figure 4: Schematic representation of the three circulation pumps and their respective connected thermal systems.	9
Figure 5: Schematic representation of the fan coils and their respective connected thermal systems.	10
Figure 6: MiniStor installed in the specially designed container, ready for shipment to the respective installation site.....	11
Figure 7: Illustration of the installed heat pump and the two fan coils inside the MiniStor container.	12
Figure 8: Illustration of a circulation pump installed with a shut-off valve integrated into the piping connections.	13

List of Tables

Table 1: Questionnaire for assessing the experiences gained during the demonstration phase at each demo site.....	14
Table 2: Responses from the pre-pilot site owners in Thessaloniki.....	15
Table 3: Responses from the laboratory managers at ÉMI.....	16
Table 4: Responses from the demo site owners in Kimmeria.....	17
Table 5: Responses from the demo site owners in Santiago de Compostela.....	18
Table 6: Responses from the demo site owners in Sopron.....	20
Table 7: Responses from the demo site owners in Cork.....	21



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1. Introduction

The Minimal Size Thermal and Electrical Energy Storage System for In-Situ Residential Installation (MiniStor) is a project funded by the European Union's Horizon 2020 research and innovation program, aiming to provide a sustainable solution for harnessing the energy efficiency potential of the European building stock. During the project's development, the MiniStor system was demonstrated and validated at five demonstration sites located in Ireland, Spain, Greece, and Hungary to test its effectiveness under different local climatic conditions, facilitating market replication while offering an innovative, efficient, and clean thermal and electrical energy storage solution for all Europeans.

This report presents the work undertaken in WP3, Task 3.2: Engineering installation strategies and prototyping for peripheral equipment. Deliverable 3.3 has two main objectives:

The first objective of this document is to provide a detailed and comprehensive overview of the peripheral thermal components integrated in the MiniStor system. This includes a description of the individual components, such as the heat pump, circulation pumps, and fan coil units. Furthermore, the document systematically addresses the interconnectivity of these components, explaining how they are linked in the overall MiniStor system.

The second objective focuses on collecting and documenting practical experiences related to these peripheral components throughout the MiniStor project lifecycle. This step includes detailed feedback gathered during the commissioning and initial operation phases at the various demonstration sites across Europe. The operational insights provided by the project partners encompass technical challenges encountered, troubleshooting measures implemented and performance observations.



2. System design

The thermal system design was initially described in detail in Deliverable 3.2, Section 2.3. Figure 1 illustrates the overall layout of the thermal system. This document focuses specifically on the selection and integration of the peripheral thermal components, namely the heat pump (HP), the circulation pumps (Pumps 3, 4, and 5), and the fan coil units. All components related to the TCM reactor and the PCM storages are described comprehensively in Deliverable 4.5. In addition, installation strategies for further peripheral equipment—including PVT collectors, PVT+HP configurations, and electrical energy storage (EES) systems—are outlined in Deliverables 3.5, 3.7, and 3.9, respectively.

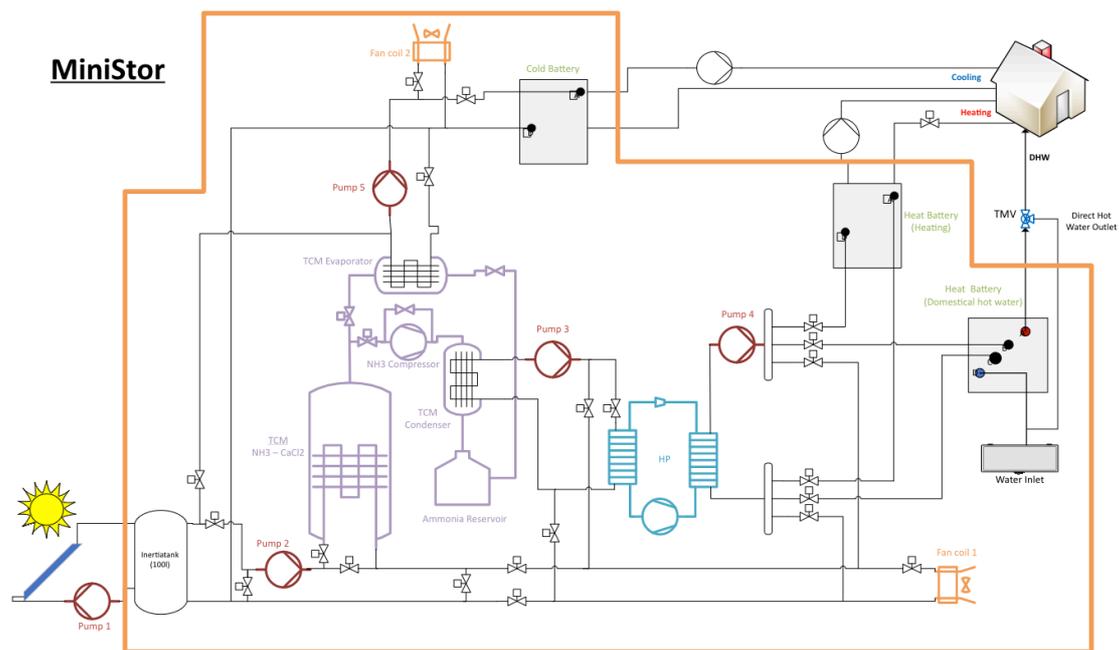
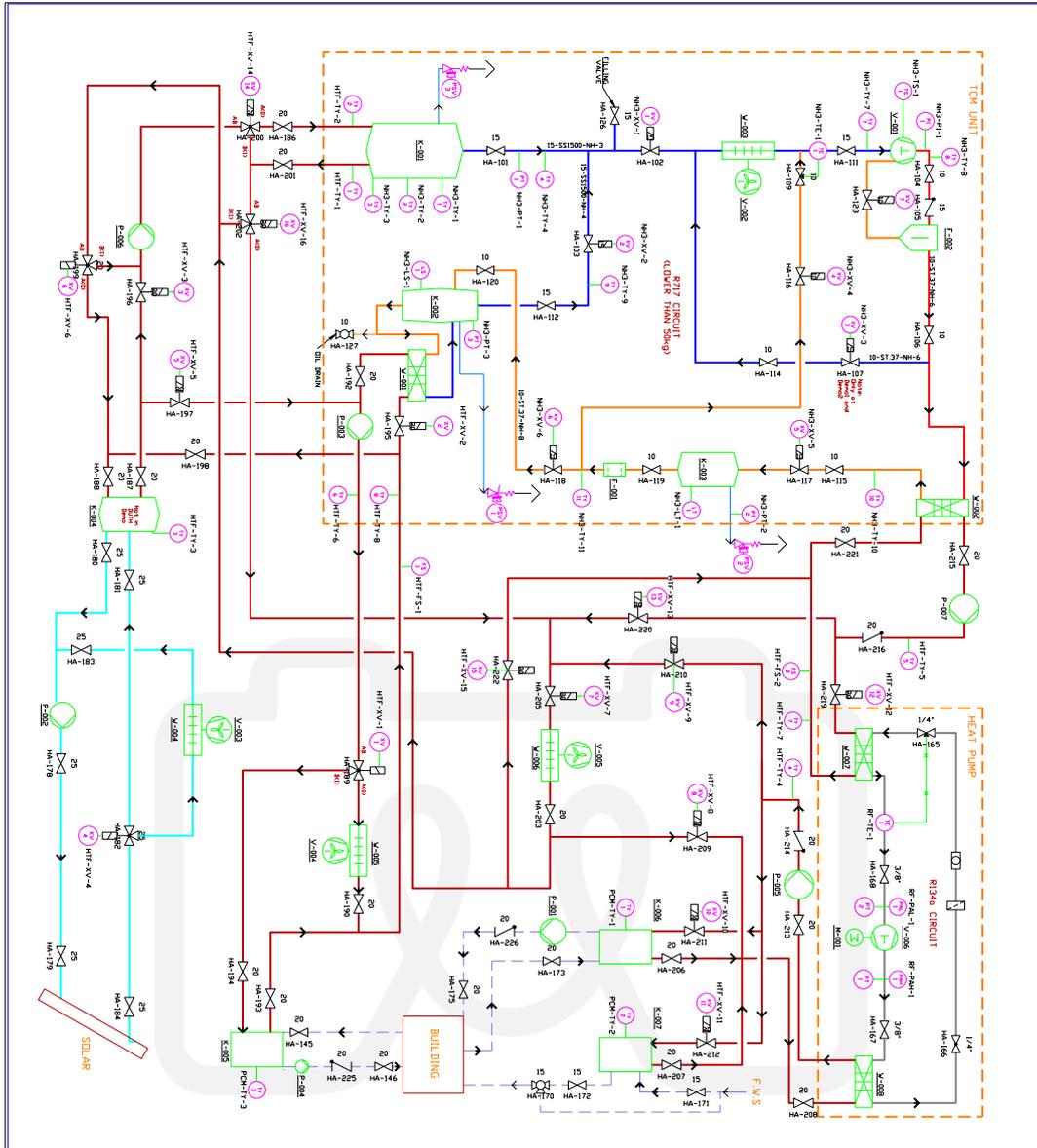


Figure 1: Schematic representation of all thermal components of the MiniStor system and their hydraulic connections.

For a comprehensive and detailed overview of the peripheral thermal components and the overall system design, the Piping and Instrumentation Diagram (P&ID) is provided in Figure 2. This diagram provides an extensive representation of the system, encompassing not only the primary components but also the peripheral components necessary for operation and maintenance.

While Figure 1 is sufficient for understanding the interconnectivity of the system as described in Section 2.1, the P&ID provides additional critical details. These include the positioning and specifications of smaller yet vital components such as shut-off valves, control valves, instrumentation points, and piping connections. The inclusion of these elements is crucial for ensuring proper system functionality, facilitating maintenance procedures, and supporting troubleshooting activities.



<p>Project Name and Address</p> <p>MINISTOR</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>#####</p>		<p>Drawing Name</p> <p>P&ID</p> <p>MINISTOR UNIT</p>							
<p>Area</p> <p>#####</p> <p>Design Number</p> <p>MINISTOR001/23</p> <p>Author</p> <p>P. BAKALIS</p>		<p>Sheet</p>							
<p>General Notes</p> <p>Fluids in TOM UNIT:</p> <ul style="list-style-type: none"> - R717 - 45%g - Refrigerant Oil Mobil SHC 226E <p>Fluids in Heat Pump:</p> <ul style="list-style-type: none"> - R334e 60%g - Refrigerant Oil Ester POE 68 <p>Heat Transfer Fluid:</p> <ul style="list-style-type: none"> - Water with 25% propylene glycol 		<p>Revision/Issue</p> <table border="1"> <tr> <td>1</td> <td>Version 001</td> <td>20.12.23</td> </tr> <tr> <td>2</td> <td>Minor Corrections</td> <td>05.01.24</td> </tr> </table>		1	Version 001	20.12.23	2	Minor Corrections	05.01.24
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Figure 2: The piping and instrumentation diagram (P&ID) of all thermal components of the MiniStor system.

2.1. System interconnectivity

The system interconnectivity of the peripheral thermal components (heat pump, circulation pumps and fan coils) is systematically presented and explained in the following section. The manufacturing processes of these components, where applicable, have already been documented in Deliverable 4.5, Section 2, particularly for components produced by the implementation partner Psycrotherm.

To avoid redundancy, this document does not revisit the manufacturing aspects. Instead, the focus is on integrating the individual components into the overall MiniStor system, highlighting their functional interdependencies and the technical interfaces necessary for successful system operation.

2.1.1. Heat pump

In winter, the heat pump (see Figure 3) raises the TCM condenser output temperature to the required charging temperature of the phase change materials (hot PCMs). Contrary to the proposal in Deliverable 3.2, a specially assembled configuration was selected to fulfil the heat pump's demanding requirements. This configuration allows the target temperature of $>63\text{ }^{\circ}\text{C}$ to be achieved with low energy consumption, even at the low inlet temperature of $28\text{-}45\text{ }^{\circ}\text{C}$. The components were selected and assembled by Psycrotherm.

The compressor used is the model 2Q3 from Dorin. The refrigerant used is R134a (1,1,1,2- Tetrafluorethan), the evaporating temperature is $10\text{ }^{\circ}\text{C}$, and the condensing temperature is $70\text{ }^{\circ}\text{C}$. The condenser capacity of 2.1 kW exceeds the required 2 kW (Deliverable 3.2, Section 3.1.1.1). According to the manufacturer, the estimated coefficient of performance (COP) is 2.43.

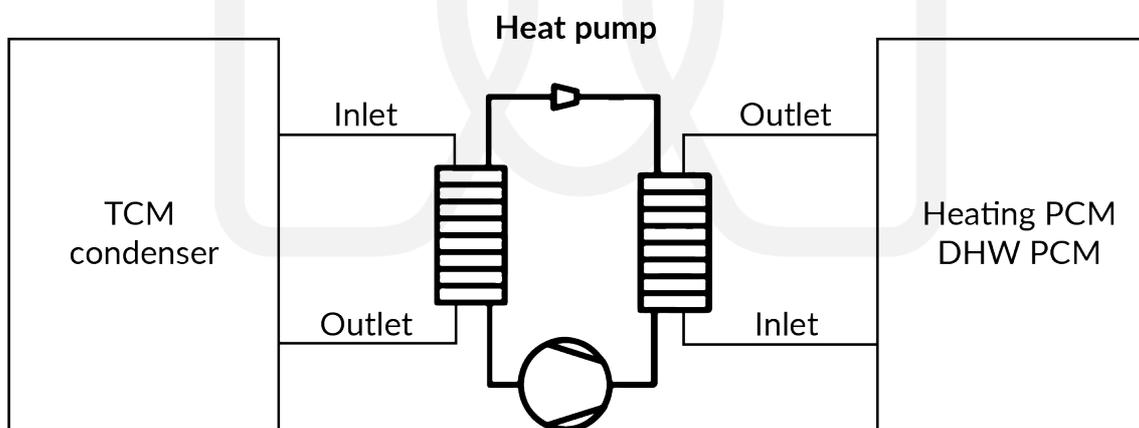


Figure 3: Schematic representation of the heat pump and its connected systems.

2.1.2. Circulation pumps

Pump 3 is responsible for supplying the heat pump and forwards the thermal power from the TCM condenser to the heat pump. Additionally, it is used to transport the excess heating power provided by the TCM condenser to fan coil 1 and to discharge the heat in the fan coil when the building's heating power cannot be utilised because the PCM storage tanks are fully charged.

Pump 4 distributes the heating power delivered by the heat pump. It supplies either the DHW PCM or the heating PCM.

Pump 5 connects the cold PCM to the TCM evaporator and the fan coil 2, offering the possibility to use the inertia tank as an additional energy source in the circuit.

Since all three pumps (see Figure 4) must fulfil similar conditions and keep maintenance and installation costs low, a commercial pump is chosen. The model NCE EI 25-60-180 from the company Calpeda meets the requirements outlined in Deliverable 3.2, Section 3.1.2.3. A recommendation for a pump model from another manufacturer can also be found there. The deviation from the recommendation in Deliverable 3.2 is due to the change in the technical partner responsible for installing the pumps. Psycrotherm is familiar with the pumps from Calpeda justifying the selection.

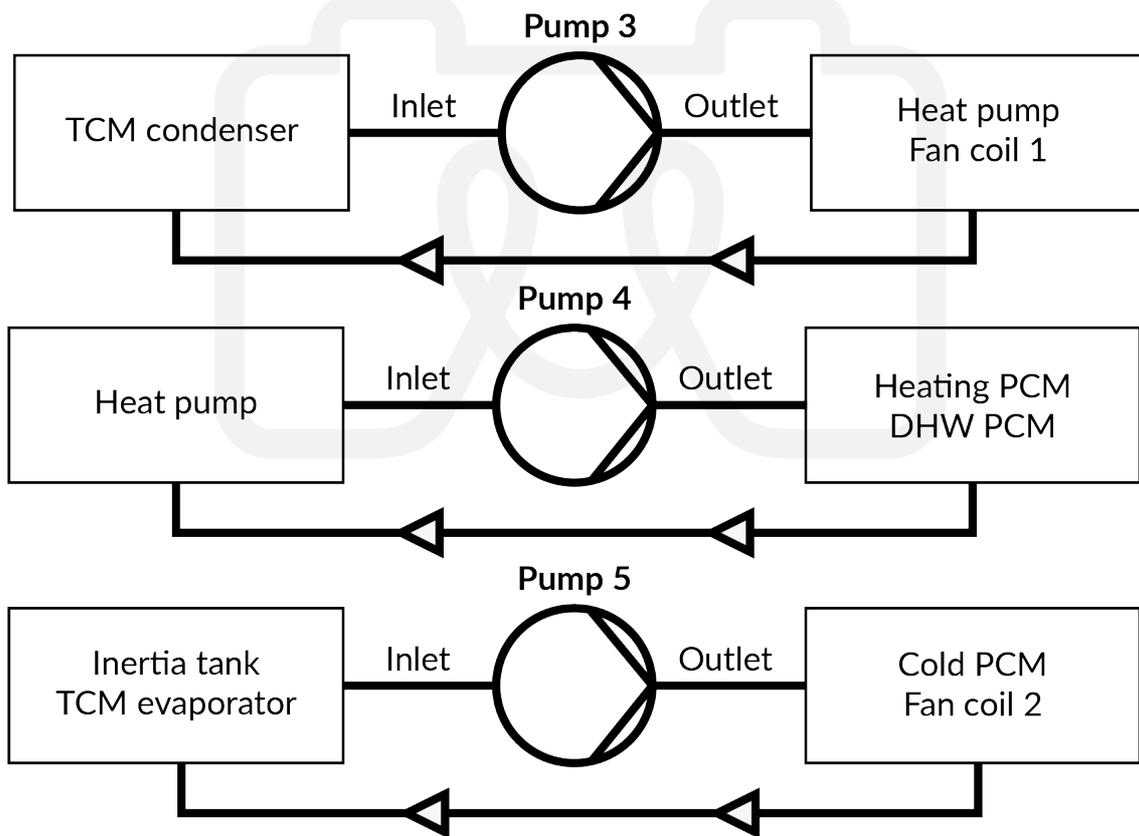


Figure 4: Schematic representation of the three circulation pumps and their respective connected thermal systems.

2.1.3. Fan coils

The two fan coils (see Figure 5) are used to dissipate excess heat from the MiniStor system when it is not in use. Fan coil 1 is integrated into the hot circuit, and fan coil 2 is integrated into the cold circuit of the system.

Fan coil 1 is active when the TCM reactor, the heating PCM, and the domestic hot water PCM are completely charged. In this case, the heating power is usually transferred directly from the TCM reactor to fan coil 1. If the TCM is not yet charged, but the heating PCM and the DHW are, the excess energy is discharged via the TCM condenser.

Fan coil 2 is active when the cold PCM is charged and no cooling is required in the house, i.e., when the ambient temperature is low. In this case, the energy is directed from the TCM evaporator to fan coil 2 and ejected there.

The requirements for the two fan coils are described in Deliverable 3.2, Section 3.1.8. A recommendation for the use of fan coils from Reventon can also be found there. In this case, as with the pumps, a different solution was chosen due to the change of the technical partner. Psycotherm has extensive experience in manufacturing fan coils and was therefore able to produce a customised solution for the present case.

The fan coils produced and installed have a nominal heating capacity of 7.13 kW with a volumetric fluid flow of 0.6 m³/h. This exceeds the requirements for the fan coils.

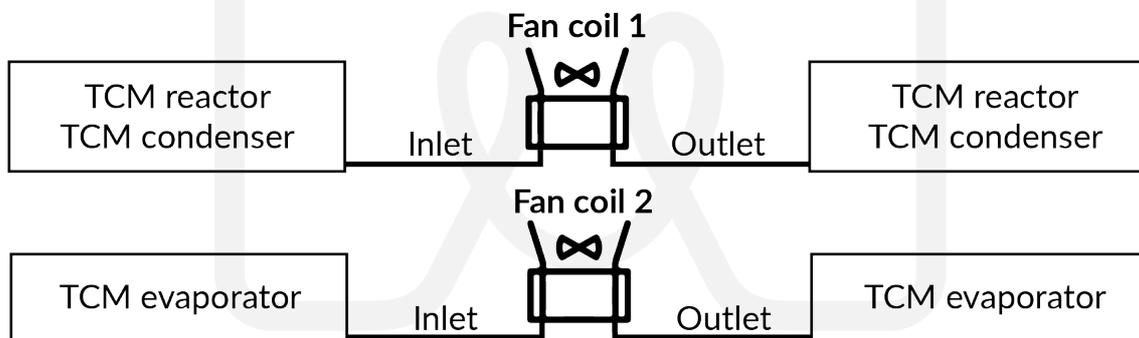


Figure 5: Schematic representation of the fan coils and their respective connected thermal systems.

2.2. Installation strategy

The installation concept for the peripheral equipment – including the heat pump, fan coil units, and circulation pumps – was developed to optimise the overall deployment process of the MiniStor system and shorten the time-on-site during installation. According to this strategy, all relevant components will be pre-installed and tested at the facilities of the implementation partner, Psycrotherm, before the final delivery of the MiniStor unit to the end-user site.

A key element of this approach is the integration of the entire MiniStor system into a purpose-built container (see Figure 6), designed and assembled by Psycrotherm. This containerised solution not only facilitates the secure and efficient transport of the system but also significantly streamlines the installation process on site. By delivering a pre-assembled and self-contained unit, the time required for on-site commissioning is considerably reduced.

This pre-assembly approach offers several additional advantages. First and foremost, it significantly reduces the complexity and duration of on-site installation, enabling faster deployment and minimising system downtime. Secondly, it ensures a higher degree of quality control, as the integration and functional testing of the peripheral components can be carried out under controlled conditions by experienced technical personnel at Psycrotherm.

Moreover, this strategy reduces the reliance on specialised technicians during the installation phase at the end-user location. By limiting the scope of work required on-site to final connections and system commissioning, the need for extensive technical expertise at the installation site is minimised. This is particularly beneficial in scenarios where access to skilled labour is limited or where the installation environment poses logistical challenges.

In summary, this forward-looking installation strategy – supported by a containerised system design – contributes to improved reliability, reduced risk of installation errors, and overall cost-effectiveness of the MiniStor deployment.



Figure 6: MiniStor installed in the specially designed container, ready for shipment to the respective installation site.

Figure 7 provides an overview of the heat pump alongside the two fan coil units. Both the heat pump and the fan coil units were designed and manufactured by the project implementation partner, Psycrotherm.

The heat pump assembly consists of three key components: the evaporator, the condenser, and the compressor. These elements were integrated into a single functional unit and subjected to preliminary testing at Psycrotherm's facilities. The purpose of this initial test run was to identify and resolve any potential technical issues at an early stage, ensuring the correct operation and performance of the assembled system. This approach enabled thorough validation of the thermal subsystem under controlled conditions, thereby reducing the likelihood of faults during on-site installation and enhancing the overall reliability of the system.

After the initial testing procedures, the heat pump was installed within the container and mechanically and hydraulically integrated with the other key components of the MiniStor system. This step marked the final stage of system assembly before shipment, ensuring full internal connectivity and readiness for deployment.

Further technical details regarding the assembly process, component specifications, and visual documentation of the manufacturing steps for both the heat pump and the fan coil units are provided in Deliverable 4.5, Section 2.

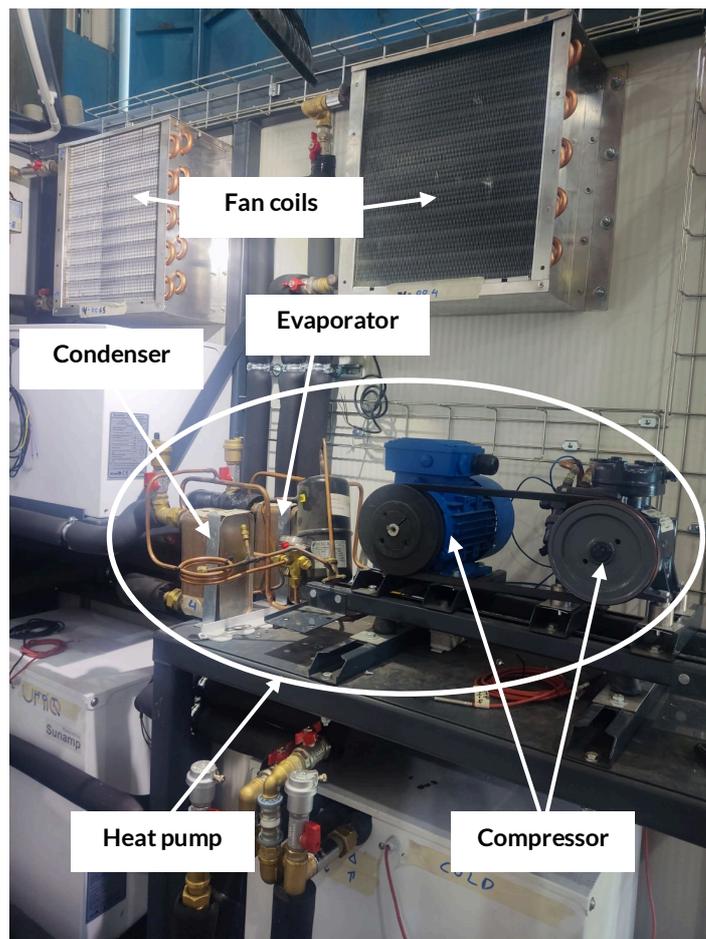


Figure 7: Illustration of the installed heat pump and the two fan coils inside the MiniStor container.

The circulation pumps (see Figure 8) were hydraulically and electrically integrated into the MiniStor system in full compliance with the technical guidelines and specifications provided by the manufacturer. This integration involved the correct configuration of flow direction, pressure ratings, and electrical control interfaces to ensure reliable and efficient operation within the thermal subsystem.

During the installation process, particular attention was given to the spatial arrangement and mounting of the pumps to guarantee adequate accessibility. This design consideration ensures that the pumps remain easily reachable for future maintenance tasks, troubleshooting procedures, or parameter adjustments, such as modifying flow rates or control settings, without the need for extensive disassembly.

Additionally, each circulation pump was equipped with a shut-off valve on both the upstream and downstream sides. This configuration allows for the isolation and removal of an individual pump without requiring the entire hydraulic system to be drained. This measure significantly simplifies maintenance procedures, supporting the overall modularity and serviceability of the MiniStor system.

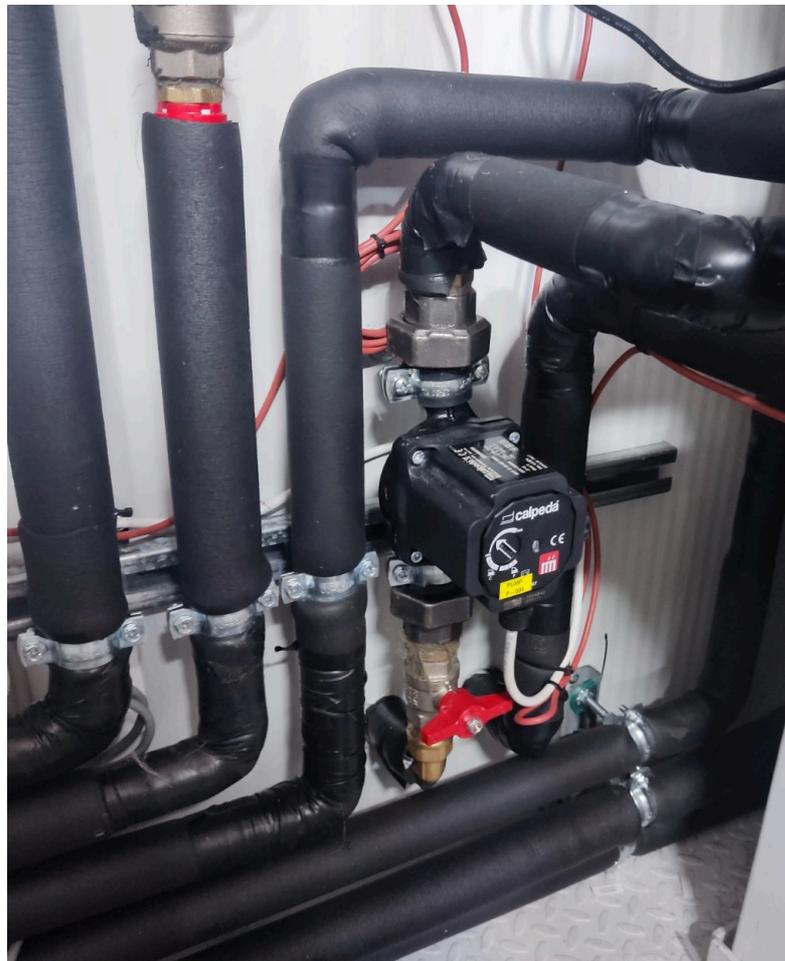


Figure 8: Illustration of a circulation pump installed with a shut-off valve integrated into the piping connections.

3. Feedback from the demonstration phase

The operational experience of the respective project partners with peripheral thermal components is a key quality attribute within the MiniStor project. To systematically capture and evaluate any issues encountered during both initial commissioning and regular operation, a structured questionnaire (Table 1) has been developed and implemented. This instrument serves to identify technical or procedural challenges that may arise not only during routine use but also during the installation phase.

To gather a comprehensive overview of practical experiences across different implementation contexts, the survey was extended to include ÉMI, which hosted the MiniStor system in its laboratory for an extended testing period. Their insights, derived from several weeks of hands-on evaluation, provide valuable feedback that has been integrated into the ongoing refinement of the system design and installation protocols.

Table 1: Questionnaire for assessing the experiences gained during the demonstration phase at each demo site.

<p>Challenges in the permit application:</p> <p>Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?</p>
<p>Site modifications:</p> <p>Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?</p>
<p>Peripheral thermal equipment Installation:</p> <p>Did you experience any difficulties when installing the peripheral equipment?</p>
<p>Impact on residents:</p> <p>Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?</p>
<p>Operational disturbances:</p> <p>Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?</p>
<p>Unexpected maintenance:</p> <p>Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?</p>
<p>Replacement of peripheral components:</p> <p>Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?</p>

3.1. Pre-pilot site in Thessaloniki

Table 2: Responses from the pre-pilot site owners in Thessaloniki.

Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?	
CERTH:	No. As a research institution, the process was relatively straightforward.
Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?	
CERTH:	Due to the installation delay, modifications were necessary, which resulted in the solar array's relocation.
Did you experience any difficulties when installing the peripheral equipment?	
CERTH:	No.
Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?	
CERTH:	No.
Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?	
CERTH:	No.
Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?	
CERTH:	Yes, during the summertime, the thermal fluid in the solar loop was replenished, and in August, the solar field was covered to prevent overheating.
Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?	
CERTH:	Two circulators were replaced, and an extra expansion vessel was added to the system.

3.2. Laboratory test at ÉMI

Table 3: Responses from the laboratory managers at ÉMI.

Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?	
ÉMI:	We did not apply for any permit because we considered the MiniStor unit to be just another sample we received during our usual laboratory tests.
Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?	
ÉMI:	The laboratory window had to be removed to connect the testing environment to the MiniStor. Piping had to be built between the two facilities.
Did you experience any difficulties when installing the peripheral equipment?	
ÉMI:	The MiniStor arrived as a single, complex built-in unit; however, its components can be turned on separately. We experienced some difficulties while operating the remote control.
Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?	
ÉMI:	No residents were involved during the test procedures.
Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?	
ÉMI:	Noise from the compressor and minor ammonia leakage were experienced, followed by compressor failure.
Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?	
ÉMI:	Change of the compressor, but it was executed by Psycrotherm.
Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?	
ÉMI:	Change of the compressor, but it was executed by Psycrotherm.

3.3. Demonstration site in Kimmeria (DUTH)

Table 4: Responses from the demo site owners in Kimmeria.

Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?	
DUTH:	We haven't faced any considerable challenges with the permit application process. The technical department of DUTH was very cooperative and understood the technical part of the project.
Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?	
DUTH:	Regarding the MiniStor's equipment, there were no modifications. From DUTH's side, a 500 liter buffer tank was installed in the C2 basement, near the rest of the building's hydraulic infrastructure, along with a separate heating and cooling collector. An additional expansion tank was also installed in complement to the previously mentioned equipment to avoid overpressure in MiniStor's hydraulic circuit. Also, two circulating pumps were installed in the same area. The first pump's purpose is to supply MiniStor's buffer Tank with hot water from the central heating collector in the C2 building. The second pump's purpose is to supply MiniStor with hot water from the 500 L buffer tank.
Did you experience any difficulties when installing the peripheral equipment?	
DUTH:	Our research team provided the contractor with all necessary diagrams and drawings, and we closely supervised the installation process. We did not face any considerable difficulties during the process.
Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?	
DUTH:	The residents were informed several months before the installation phase to explain the purpose of the MiniStor, its ammonia content, and to encourage them to ask questions. They were enthusiastic and very supportive regarding the installation of the fan coil units in their rooms, with some witnessing a fan coil installation for the first time. They showed great interest in learning how the system works, and none of them raised any objections.
Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?	
DUTH:	No, haven't noticed any disturbances, expect a leakage from a failed pump.
Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?	
DUTH:	Yes, some minor maintenance was required. The NH₃ charging sensor had to be calibrated several times. Additionally, a pump failed, resulting in a water leak that had to be replaced by Psycotherm.
Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?	
DUTH:	Yes. A pump had failed, resulting in a water leak and had to be replaced by Psycotherm.

3.4. Demonstration site in Santiago de Compostela (USC)

Table 5: Responses from the demo site owners in Santiago de Compostela.

	Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?
USC:	We encountered no special obstacles during the permitting process because the MiniStor system components were installed on our premises. No excavations were required for their interconnection, and most components were pre-installed in the MiniStor container.
	Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?
USC:	The USC demo site is an apartment in a building used as a university residence. Before installing the MiniStor system, adaptation work included installing a heating system independent of the building and monitoring the apartment's energy consumption and environmental conditions. Additionally, the area for installing the solar panel field has been prepared.
	Did you experience any difficulties when installing the peripheral equipment?
USC:	We experienced a failure in the indoor unit of the Hitachi heat pump, apparently due to a poorly performed weld, which was subsequently repaired. One of the solar panels had a hydraulic leak, which was repaired during the installation process. The installation of the air vents in the hydraulic system of the solar panel field gave problems due to the position of the connections. The anti-vibration mounts of a compressor were damaged due to blows received by the MiniStor container during local transport by the crane service company. The compressor was somewhat displaced from its mounting position. Also, some units had loose fixing elements.
	Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?
USC:	The work to assemble the MiniStor system components did not require heavy or noisy machinery, except the crane truck needed to unload the MiniStor container and the support beams for the solar panels. The estimated time for each task was one hour. Additionally, the bulk of the installation process was completed during the holiday period.
	Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?
USC:	The system at the USC demo site is still being commissioned. It is more complex than other demo sites because it features an additional heat pump and must be integrated into the USC SCADA system. Remote control of the HITACHI heat pump and the operation of its second stage still need to be tested, as well as programming the behaviour of the integrated system and eliminating any duplicate components.
	Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?

USC:	The system at the USC demo site is still being commissioned. It is more complex than other demo sites because it features an additional heat pump and must be integrated into the USC SCADA system. Remote control of the HITACHI heat pump and the operation of its second stage still need to be tested, as well as programming the behaviour of the integrated system and eliminating any duplicate components.
Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?	
USC:	Although we are still in the final phase of the commissioning process, we had to replace a pressure gauge, its fitting, and the anti-vibration mounts of one of the compressors. Additionally, due to a manufacturing defect, we had to modify the connection between the HITACHI heat pump and the buffer tank.



3.5. Demonstration site in Sopron

Table 6: Responses from the demo site owners in Sopron.

Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?	
SOPRON:	No, the amount of ammonia in MiniStor is far below the accepted limit in Hungary. For ammonia only industrial restrictions are valid, but this is about 1000 kg.
Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?	
SOPRON:	Yes. An additional 50-liter extension tank was installed in the system. The tank was connected by professionals from Psycrotherm. As a second modification, the Psycrotherm technicians replaced the inverter that controls the operation of the ammonia compressor. After the replacement, the compressor functioned perfectly.
Did you experience any difficulties when installing the peripheral equipment?	
SOPRON:	No, the connection of peripheral parts was done according to the instruction of Psycrotherm and Endef without any problem. We received very detailed descriptions and drawings.
Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?	
SOPRON:	Minimal disturbance occurred during the pipe placement, as trenching was limited. The connection to the building's heating and domestic hot water (DHW) systems was also done with minimal disruption. The delivery and placement of the MiniStor in its designated location were quick and easy. The compact, containerised solution made the process very convenient. The setup, excluding pipe connections, was completed within one hour. Commissioning was completed in two days, with no noticeable noise or dirt. In summary, no significant disturbances occurred. Fortunately, the timing was ideal, as the installation took place on working days when the residents were at home only in the morning and afternoon.
Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?	
SOPRON:	Physically, there was no disturbance at all. There are two sources of noise. The first is the cooler part of the solar system. To minimise this noise, the cooler, equipped with its fan, was installed on the side of the MiniStor opposite the demo building. In this way, the MiniStor container acts as a sound barrier, effectively shielding the noise. The noise generated by the MiniStor itself is also low, as the container provides a noise-reducing effect. So far, no disturbances have been reported.
Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?	
SOPRON:	We also experienced a sealing issue in the solar system, but this was fixed easily.
Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?	
SOPRON:	Inverter was changed and an extra 50-liter expansion tank was built in.

3.6. Demonstration site in Cork

Table 7: Responses from the demo site owners in Cork.

Did you face any challenges during the permit application process due to the peripheral systems (fans, pumps, heat pumps)? Were there any obstacles related to local regulations or environmental standards concerning these systems?	
	No challenges or obstacles were encountered during the permit application process.
Were any modifications to the site necessary due to the peripheral equipment (fans, pumps, heat pump) to prepare for the system's installation?	
	Yes, trees had to be removed to facilitate the solar panels and prevent shading. Other modifications such as placing ducting on site to run piping underground from MiniStor to the house and to run cables from the shed to the house for the inverter and batteries.
Did you experience any difficulties when installing the peripheral equipment?	
	During the installation process, Installation contractors required more information for all installation procedures. Example: The pipe connections at the rear of the MiniStor container had to be verified with Psycrotherm. Battery and inverter connections had to be verified with ENDEF. Some leads and manuals were not included with the batteries.
Did the residents experience any disturbances during the installation phase? Where are disturbances related to the installation of the peripheral equipment (fans, pumps, heat pump)?	
	No disturbances noted.
Have you noticed any disturbances during the system's operation, such as noise, exhaust, or chill from the fans, pumps or the heat pump?	
	No.
Have there been any unexpected maintenance tasks related to the peripheral equipment since the system was installed?	
	A seal on the drive of the compressor had to be replaced. A Raspberry Pi device had to be installed in the MiniStor unit to ensure connection with IoT.
Have you had to replace any peripheral components (fans, pumps, heat pump) since the system was put into operation?	
	During commissioning, a seal replacement for the shaft of the ammonia compressor was required. It was sourced locally and replaced on the same day.