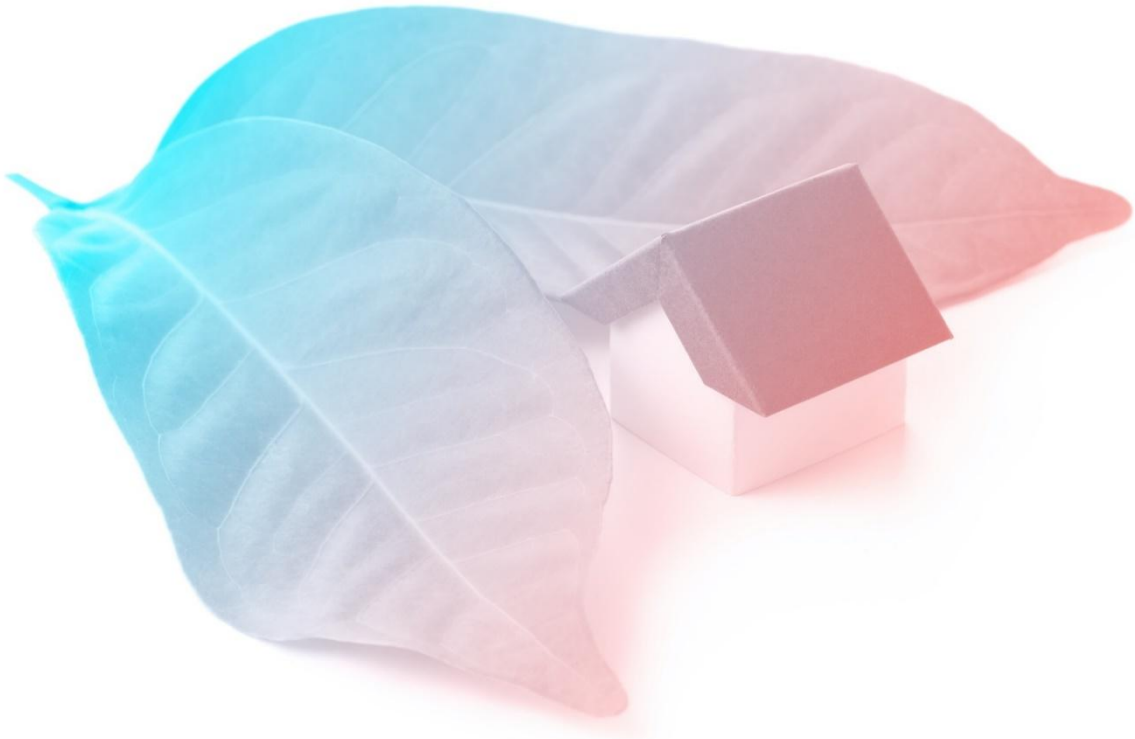
This project has received funding from the European Union´s Horizon 2020 research and innovation programme under the grant agreement No 869821

D7.8 Replication Plan



Marco Rocchetti (R2M)

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D7.8 Replication Plan

Summary

This deliverable presents the final report from WP7 and contains the results from the exploitation activities obtained during the project life. This deliverable follows the preliminary exploitation report D7.4 and updates the list of exploitable results (ERs) identified in the project characterizing all of them in a detailed exploitable result table (final version 6). The process of innovation management identified five Key Exploitable Results (KERs) for the list of ERs based in selection criteria considering qualitative and quantitative parameters. The KERs have been analysed using the BOSAT methodology to identify lacks and needs for a technology readiness level upscaling that brings it closer to market. The report concludes the exploitation treatment with a list of lessons learnt by each partner and a detailed plan for the replication of the knowledge and the results obtained. The analysis finds that the system as a whole can benefit from further refinement based on experiences gained during the demonstration phase, while widespread market penetration needs to consider current regulations that are more geared towards industrial application. Several sub-products are ready for promising future development.

Deliverable Number	Work Package
D7.5	WP7
Lead Beneficiary	**Deliverable Author(S)**
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Beneficiaries	**Deliverable Reviewers**
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Planned Delivery Date	**Actual Delivery Date**
30/04/2025	04/06/2025

Type of deliverable	R	Report	X
Dissemination Level	PU	Public	X

Table of Contents

List of Tables

List of Images

Abbreviations

AR/VR	Augmented Reality / Virtual Reality
BESS	Battery Electrical Storage System
BM	Business Model
BMC	Business Model Canvas
BO	Business Opportunity
COP	Coefficient of Performance
D.x	Deliverable #
DER	Distributed Energy Resources
DHC	District Heating and Cooling
DHW	Domestic Hot Water
DR	Demand Respond
EPC	Energy Performance Contract
ER	Exploitable Result
ESCo	Energy Service Company
EPC	Energy Performance Contract
EPSM	Environmental Performance Strategy Map
GUI	Graphical User Interface
HEMS	Home Energy Management System
HP	Heat Pump
IEQ	Indoor Environmental Quality
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Right
KER	Key Exploitable Result
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LHS	Latent Heating Storage
LoD	Level of Detail
M.x	Month #
ML	Machine Learning
NDA	Non-Disclosure Agreement
O&M	Operation and Maintenance
PCM	Phase Change Material
PV	Photovoltaic
PVT	Photovoltaic Thermal Panel
RES	Renewable Energy System
SHS	Sensible Heat Storage
SME	Small Medium Enterprise
SoA	State of the Art
TCM	Thermo Chemical Material
THS	Thermochemical Heat Storage
TRL	Technology Readiness Level
UI/UX	User Interface / User Experience
UVP	Unique Value Proposition
VP	Value Proposition
VPC	Value Proposition Canvas
WP	Work Package

Disclaimer

The information contained in the document reflects only and exclusively the point of view of the author. The European Commission is not responsible for any use that may be made of this information.

This deliverable has been conceived using R2M's exploitation methodology, which has been developed across time as R2M has fulfilled this role in several EU projects. Although continuous improvements happen, the core of the methodology is common to other deliverables and, for this reason, the table of contents, some pictures and some text modules are similar to other exploitation deliverables developed in the framework of previous projects and defined ad replication plan.

The contents here are project-specific and are the main result of R2M's and all contributors' effort in creating this report.

Introduction

Launched to contribute to the challenge of providing innovative thermal storage solutions for the residential sector, the MiniStor project proved the sustainability of relevant innovations that can reduce the environmental impact of buildings by supporting the integration of renewable energy systems (RES) and reducing the use of carbon-based fossil fuels for heating, cooling, and producing domestic hot water (DHW).

The overall objective of the MiniStor project is based on the design and development of a novel compact, integrated thermal storage system, tailored to satisfy the energy needs of new and existing residential buildings. The core innovation is its thermal storage system based on a high-performing $CaCl_2/NH_3$ thermochemical material (TCM) reaction, combined with hot and latent heat storage based on phase-change materials (PCM). The system is also equipped with a conventional electrical storage based on a Li-ion battery for the improvement of energy flexibility. The MiniStor system allows for compact storing of RES-based energy such as hybrid photovoltaic thermal panels (PVT). This system can be considered as an integration of project results and innovation working in joint exploitation.

One objective of the "Market analysis, Impact maximization, business model & innovation knowledge enhancement" Work Package 7 is to define at an early stage the exploitation strategy of the MiniStor Project. This work package includes the management of exploitable results throughout the project, Intellectual Property Right (IPR) aspects, commercial agreements where necessary (e.g. licensing between the partners), market analysis and business modelling.

This report represents the final analysis of the exploitation activities started at M3 and presented, in preliminary version, in the D7.4 "Exploitable Result Table" at M6. It provides a final overview on the identification and characterisation of the Exploitable Results (ERs), preliminarily identified and listed in the D7.4, and the process of selection of Key Exploitable Results (KERs).

The KER table is a key tool in the exploitation process because it contains key aspects for the other tasks as the Market analysis and the Business modelling. The KER table identifies five results that are considered more mature and ready to be brought to market in the medium to short term, respect to the other project results. This means they have a good opportunity to reach the market quickly and guarantee replication.

The process of identifying KERs, as detailed in Chapter 3, 'MiniStor Key Exploitable Result Definition', was also used as input for T7.4, 'Business Modelling and Market Introduction', as the analysis produced a business model assessment for each KER, as presented in D7.5, 'MiniStor Business Model'.

1. The MiniStor Replication methodology and context

1.1 Exploitation Methodology

The exploitation objective is to explore the innovation of MiniStor and unlock the potential and innovation capacity of the project through the identification and management of both existing and new products, services and knowledges developed and optimised within the project.

This activity started in the first year of the project, included in Task 7.3, producing the first ER list as part of the deliverable D7.4. After that, the IPR assessment continued in the rest of the exploitation plan as a continuative activity. It required several iterations between the result owners and R2M, in form of bilateral meetings and discussion until the definition of a IPR protection strategy based on a consolidated company business vision and aligned whit the MiniStor context.

At the same time, the characterisation of the ERs has been completed by the contribution from the partners (ER owners and contributors) and the definition. This activity has the objective to maximise the impact of the results within the project, identifying bottleneck and promoting mitigation measures depending on the project evolution and the changes that appended in the project consortium.

The selection of KERs, here described in the chapter 3, is an activity included in the exploitation process that aims to identify the most promising and important Exploitable Results. The selection, based on defined criteria, uses also the risks and impact analysis (described chapter 3.2) as part of the selection process

The final part of this activity, placed in the last period, works to finalise the ER table and to plan the replicability for them.

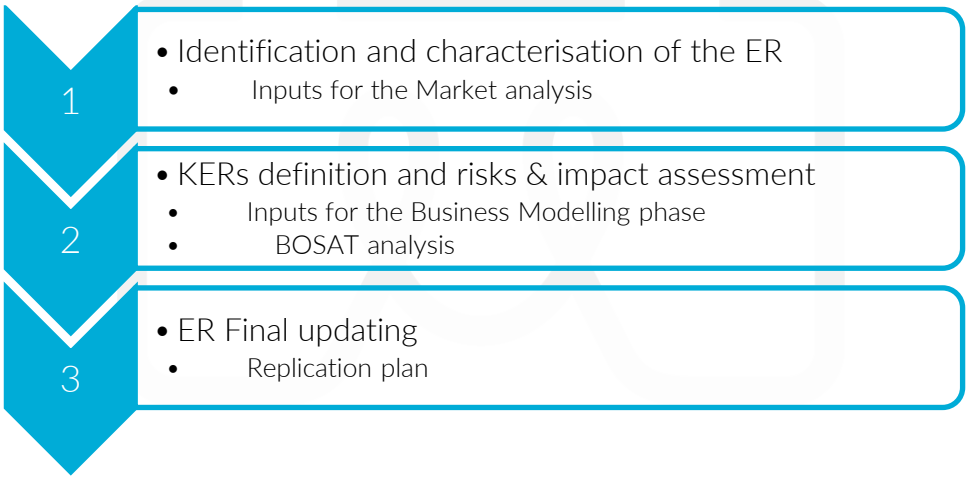

Figure 1. Three main steps for the Exploitation framework

1.2 Responsibilities and Leadership

Based on the above methodology, each partner "owns" the respective results (in terms of leading the information development of the ER) and therefore provided all the data required for the definition, management and finalisation of the ER during the WP7 period. The documents used for data collection were distributed in different project periods:

- Identification of ERs through the Exploitation Table (M4), used to identify the outcome and plan the MiniStor Exploitable Strategy.
- Gathering Information Template (M24) through the second version of the Exploitation Table, used to characterise the ERs and obtain information on branding and market awareness, useful for the market analysis.
- Gathering Risks and Impacts Template, (M40) used to gather information on market risks and commercialisation impacts to define the selection of KERs and the starting point for the replication plan.

1.3 Target Audience

The main target audience of this report is represented by the MiniStor partners which own the project results and whose work is related to the definition of the replication plan of the MiniStor system.
The report aims to (i) finalise the ERs analysis, (ii) identify the KERs and (iii) draft a replication plan, so every partner interested in future synergic activity with the IPR owners, is encouraged to use this report.
A Special interest in the Replication Plan is targeted to the KERs owners in relation to the detailed BOSAT assessment reported for each KER.

1.4 Policy and Regulation Framework

The use of ammonia as an energy carrier, or in energy systems in Europe is subject to an evolving regulatory and technical framework, incorporating European regulations, international standards and specific guidelines for sectors, such as shipping and industrial refrigeration, which may directly impact the replicability of the MiniStor project and the exploitation strategy after the project's end.

Even though a review of standards and regulations has already been carried out in the companion reports and deliverable D2.3, it is worth highlighting two fundamental safety standards and regulations related to the use of ammonia for a clear assessment of MiniStor's replicability.

The main applicable regulations and safety standards related to the use of ammonia:

- Directive 2012/18/EU: This directive sets standards for the prevention of major accidents involving dangerous substances, including ammonia. Companies operating facilities with significant quantities of ammonia must adopt safety measures, emergency plans and communication procedures to protect human health and the environment.[1]
- European Technical Standards EN 378: The EN 378 series of standards provides safety requirements for refrigeration systems and heat pumps, including those using ammonia. These standards cover aspects such as installation, operation, maintenance and personal protection, helping to ensure the safe use of ammonia in industry.[2] This regulation is applicable in several EU countries with local specific restrictions that limit the amounts of ammonia to be used.

Ammonia and ammonia systems are widely used in industrial and commercial applications, such as refrigeration and power generation, due to its superior thermodynamic properties and low environmental impact.

The MiniStor project focussed the analysis about the integration of ammonia TES in residential sector, defining them as the primary customer segment. In general, the use of ammonia in residential applications is limited and subject to specific regulations that vary between European countries, but the benefits, in terms of CO_2 emission reduction that it is possible to achieve in this application have great potential impact. This is one of the reasons why the primary customer segment has been identified as the residential sector.

During the project we understood that there are great opportunities for the applicability of the system in other customer segments such as sports and wellness centres, hotels, but current ammonia regulations limit MiniStor applicability.

Nevertheless, it is essential that local regulations are consulted to ensure compliance and safety in the use of ammonia. Those aspects are fundamental for the replicability of the MiniStor system, especially for the residential application.

[1] https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:32012L0018&from=IT
[2] https://area-eur.be/sites/default/files/2019-07/AREA%20Introduction%20to%20EN%20378%20-%20for%20Publication_0.pdf

2. MiniStor Exploitable Results Characterisation

The process of characterising the MiniStor Exploitable Results starts after the submission of the D7.4 "Exploitable Results Table", submitted at M6. In the D7.4, the first version of the Exploitable Results Table was identified taking into account an initial list of 22 results defined as innovation for the project (Annex II).

The ER table has been considered as a living tool that changes according to project evolution, technical and scientific activities of the consortium partners.

This process influenced the ER table, reducing the list of results from the initial value of 22 to the final value of 19:

- The ER#14 "Latent Heat Storage (LHS) Unit with PCM materials" and ER#15 "Water circuits and PCM Heat Exchanger" have been removed from the ER table as the PCM applied in the unit is a commercial product readily available.
- The ER#19 "MiniStor Startup" has been removed because it is not a project result but part of the proposed synergic replication plan and the business model.

The final ER table is shown in this report as Table 2.

In this process, under the leadership of the Exploitation manager, R2M worked managing ER's information collected from the partners about the ERs

The final characterisation of ERs identified 5 ERs as product, 4 as software, 8 ERs as knowledge and 2 as models (Figure 2). The main contributions for the definition of the ERs came from the WP3 and the WP5 as presented in the Figure 3.

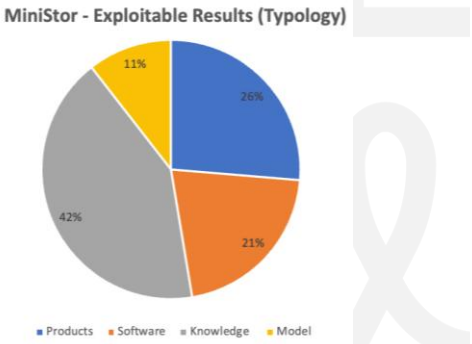

Figure 2. ERs characterization by type

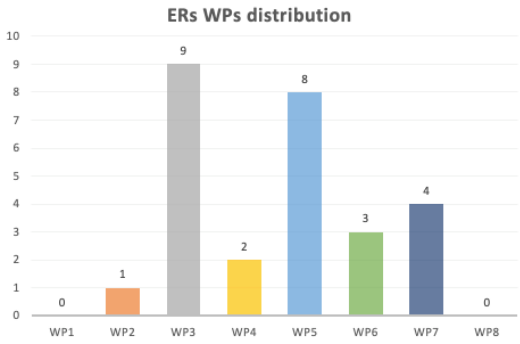

Figure 3. ERs characterization by WP

The progress of the project and the impact on the ER has been monitored considering the TRL level at the beginning of the project and the expected TRL level at the end. This analysis reached the expectation with all the ER reaching the TRL7, as planned in the proposal phase and shown the Table 1. The TRL has been monitored in accordance with the indication of the Horizon Europe programme about the innovation readiness.[3]

The results of MiniStor have been classified in base of the innovation level as presented in the Figure 4, following the Triz theory (detailed in chapter 3.1).

Another important aspect monitored by the exploitation process is level of protection for the innovation introduced and generated into the project. The protectability of each ER has been considered bilaterally, with the ER owners. Some ERs are already covered by IPR as the PVT panels from EndeF. In the other chases, the innovation management proposed the best solution for the final protection of the ER.

As a result of this process, the Table 2 collects all the information needed for the interaction with the other work packages, the final business modelling and the project replicability.

[3] https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

Table 1. TRL monitoring table

ER#	ER Name	TRL Level	0	1	2	3	4	5	6	7	8	9
ER1	MiniStor Compact Energy Storage							5		7 7		
ER2	Software model to implement the system in state-of-the-art whole-building energy modelling programs								6	7 7		
ER3	Home Energy Management System (HEMS)							5		7 7		
ER4	Visual Interface IoT-platform for user interaction							5		7 7		
ER5	Enhanced Energy Modellers (DR forecasting)								6	7 7		
ER6	Cloud base monitoring Tool and data mine								6	7 7		
ER7	HEMS - High level control							5		7 7		
ER8	Distributed Energy Resource (DER) prediction model								6	7 7		
ER9	Novel PVT System							5		7 7		
ER10	Water flat plate PVT collectors (Convencional PVT)							5		7 7		
ER11	Strategies for connecting Conventional PVT, with the TCM storage							5		7 7		
ER12	Hybrid Energy Storage testing procedures							5		7 7		
ER13	Thermochemical Unit (TCM)							5		7 7		
ER14	Stratgies fro integration of BESS Unit with TES							5		7 7		
ER15	MiniStor time and cost-effective construction methods		N/A									
ER16	MiniStor footprint impact tool								6	7 7		
ER17	Circular economy Ministor Business Model		N/A									
ER18	AR/VR interaction with end-users							5		7 7		
ER19	Methodology for Ministor O&M							5		7 7		

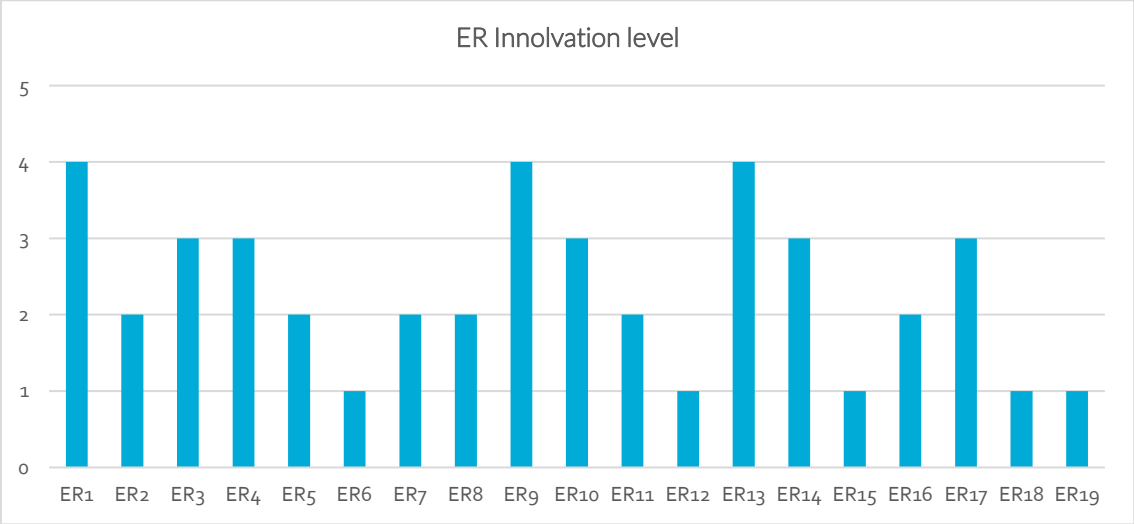

Figure 4. ERs Innovation level

Table 2. Final Exploitable Result Table – ER table version 6

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
1	MiniStor Compact Energy Storage	Product	WP3, WP4, WP5, WP6	Joint Ownership: CNRS (P), CERH (P), CARTIF (P), EndeF (P), Sofrigam (P), Psyctotherm (P), etc.	TRL7	Patent and Copyright	4	R2M, IREC
Description: The MiniStor Compact Energy Storage is an integrated system composed by two thermal energy storage technologies (TCM and PCM), one Li-ion electrical storage and integrated in a tailored wat by RES such as HP, PVT and PV panels. The management of the systems is guaranteed by an innovative HEMS that interacts with end users via a visual tool and a human-centric approach. The MiniStor system uses energy generated from renewable energy sources (RES) to produce heating, cooling and domestic hot water (DHW) for residential applications. The storage systems enable energy flexibility by storing excess energy during periods of low demand. It is characterised by a compact volume tailored for residential applications. The size of the storage is estimated at 0,72 m^2.					**Innovation**: The thermal storage system will be based on a high-performing $CaCl_2$/NH3 TCM reaction, combined with hot and latent heat storage based on PCM. Overall system storage density is extremely high, up to 10,6 times higher than water-based storage systems for operating heating temperature difference in the range of 15°C (around 182 kWh/m^3). The MiniStor design minimizes the respective installation costs, while the compactness of the system facilitates its scalability to a wide range of buildings and at a district and urban level. The system has a coefficient of performance (COP) of 1.8, that will cover net energy consumption while storing heating and cooling for later use on demand.			
Exploitation Potential: The ER is characterised as KER#1 and the exploitation potential is deeply analysed in the MiniStor Business Model. Considering it is a joint result the exploitation strategy takes in consideration the commercialisation model where each partner maintains the ownership of their IPR and participate in a common business. This model can be represented by a Newco participated by the partners, that operates directly into the market. The lessons Learnt by the partners in the MiniStor development and commissioning phases can be also used in dissemination or scientific knowledge.								
#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
2	Model to implement the system in state-of-the-art whole-building energy modelling programs	Model	WP3	IERC (O)	TRL7	Licensing and copyright	2	IREC

Description: The ER is represented by the computer code (model) that will be used in leading whole-building energy modelling packages to represent the energy saving brought by the system. The model supports the definition of the end users' needs to define the tailored MiniStor solution.	**Innovation**: The system could be represented using multiple energy simulation objects, which might not be accurate as modellers need to find specific physical characteristics of each element, which might not be the exact ones being used in MiniStor. It would bring convenience and timesaving by having a pre-defined system in these programs. The object could expand in the simulation program presenting to the user multiple objects at once and readily connected.
Exploitation Potential: Development of software for energy modelling in residential application. Collaboration with software hoses or internal development.	

#	ER Name	Type	WP	Owner (O) Partner (P)		IP Protection	Innovation Level	ER Manager
3	Home Energy Management System (HEMS)	Product	WP5	CARTIF (O CERTH-ITI (P) HSLU (P)	TRL7	Copyright	3	CARTIF

Description: The MiniStor HEMS represent the control of the entire system and manage the energy from the production (RES) to the end-user (building) through the exploitation of the flexibility in the storage systems. HEMS will be used to synchronise and efficiently manage the overall supply and demand at household level, responding for grid constraints and price signals. Additionally, forecasting and demand profiling (DER) will be used to effectively control the overall system and optimally exploit storage capabilities offered by MiniStor, taking into consideration any heating or electric grid constraints and prices signals.	**Innovation**: In the project, a mixture will be applied of non-intrusive, intelligent controls via personalization and context-awareness. It will also have interoperability, extending this intelligence to other devices or appliances at home, effectively multiplying its reach and impact. Continuous real-time monitoring of residential building energy performance will be made. MiniStor will demonstrate an intelligent lightweight system, tailored to the characteristics of each residential building, using raw data from IoT middleware to forecast key operational parameters and enable automation. This system will be part of the HEMS, thus ensuring high levels of occupant comfort and Indoor Environmental Quality (IEQ) in parallel with energy efficiency aspects. With a view to further increase the smart-readiness of heating network renovated buildings, the IoT supporting platform will allow direct link of in-use performance data with building context data to provide efficient guidance and incentives to owners and tenants. No other existing solution can claim this combination of functionalities and features, given the excessive fragmentation of current interfaces and protocols
Exploitation Potential: HEMS aim to offer reduced energy costs and energy flexibility to customers through IoT enabled advanced prediction services and user interaction HEMS will be initially used by the pilot sites but will be designed to scale up in larger community. The TRL upscaling will integrate new services which can be easily developed and integrated by the synergic collaboration with external suppliers of sensors. The first application is oriented to	

meet the residential end users' needs, but other customer segments are represented by applications within Smart Cities context, due to the nature of management of the municipal buildings (retirement homes, sport centres, universities).

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
4	Visual interface IoT-platform for user interaction	Software	WP5	CERTH-ITI (O)	TRL7	Copyright	3	CERTH-ITI

Description: The IoT platform for the MiniStor system will enable it to communicate directly with new generation (IoT) electrical appliances and help tenants execute recommendations from the Smart HEMS. It will be accessible via a smart end-user interface to enhance the interaction between end-users the MiniStor system and other home appliances connected to the IoT. Users will provide and obtain feedback about comfort and satisfaction with domestic services. This information will feed the controller in terms of restrictions to the optimization problem and/or inputs about expected behaviour.

Innovation: The Internet of Things (IoT) platform will enable new generation "smart" appliances to connect with each other and with smart management systems. The IoT-platform will provide recommendations on efficient energy use patterns maximizing benefits of overall energy management.

Exploitation Potential: This IoT platform aims to bring together novel sensing and actuating technologies, smart storage and RES in order to serve the user needs. In this rapidly evolving market of IoT, this platform will offer a full suite for the energy monitoring and control of each home both for electricity and heating/cooling. This prototype will evolve from the pilot sites feedback and scale up to target a wider audience. Potential applications are relevant but not limited to the Smart Cities context.

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
5	Enhanced Energy Modellers (DR forecasting and optimization tool)	Software	WP3, WP5	CERTH-ITI (O)	TRL7	Copyright	2	CERTH-ITI

Description: A DR Flexibility Forecasting & Optimisation Tool enables deep energy simulations coupled with forecasting of building energy flexibility, based on extracted profiles and current contextual conditions. It will be furthered to include heating and cooling from PCM and TCM storages.

Innovation: Demand response provides the opportunity to reduce or shift electricity usage during peak periods in response to time-based rates or other forms of financial incentives, playing a significant role also in the operation of the electric grid. This concept will be extended to cover to further include heating and cooling loads to provide different flexibility options and modes to the end users.

Exploitation Potential: Potential cases: Small scale generation plants and renewable assets integrated to the grid that produce energy and would like to respond to prices in order to sell excess to the grid. The combination of electricity and heating storage makes it a key tool for providing flexibility in a rapidly growing market. The study of different demand-response modes will lead to knowledge exploration and exploitation as well.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
6	Cloud base monitoring Tool and data mine	Software	WP4, WP5	CARTH-ITI (O) HSLU (P)	TRL7	Copyright	1	CERTH-ITI
Description: A sensor / monitoring tool will be responsible for collecting indoor and outdoor environmental data from the household and transfer them to a cloud-based secure repository for selected stakeholders such as end-users to access it remotely such as with a web-service API.					**Innovation**: This repository will also act as a 'data mine' providing required static and dynamic data for innovative algorithms and services to the Smart HEMS. The system will have the possibility to check for inconsistencies, data gaps, etc. and apply pre-processing for data quality. Finally, the monitoring tool will be also capable of performing mathematical calculations and computing the required KPI values.			
Exploitation Potential: A sensor / monitoring tool for data management has a wide exploitation potential since it can be used in a variety of applications not only limited to energy and smart cities applications. It is a tool that brings the data closer to service providers and provides a standard way of communication.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
7	HEMS - High level control	Knowledge	WP5	CARTIF (O)	TRL7	Copyright	2	CARTIF
Description: Logical protocols will be defined for decision-making based on most usual operational situations, as well as responses that should follow to those decisions. The responses will be directed towards optimal use of the thermal and electrical sub-systems according to the specific case being presented.					**Innovation**: The defined protocols will be specifically design for the equipment to be used in the scope of the project. Self-learning software architectures will be used if deemed necessary in order to present a personalized experience for each household.			
Exploitation Potential: This result is integrated in the HEMS, and it is considered one of the MiniStor KERs. Knowledge acquisition and transfer will be exploitation strategies as well as the direct sale of service and / or knowledge learner by CARTIF. Training programmes will also be considered.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
8	Distributed Energy Resource (DER) prediction model	Model	WP5	CARTIF (O)	TRL7	Copyright	2	CARTIF

Description: Development of abilities for the energy management system to predict availability of RES, which will allow it to prepare for optimal operation modes based on the abundance or lack of that resource.	**Innovation**: The proposed methods will be Distributed Energy Resource (DER) forecasting based on weather predictions and reports, and the use or demand profiling. Initial methods of DER forecasting will include macro area weather forecasts, but the availability of modifying those forecasts for micro climatic zones will be investigated. Demand profiling for thermal load forecast will serve to predict the amount of energy needed to reach a certain comfort level and target setpoint temperature, coupled with the availability of stored energy.
Exploitation Potential: Knowledge acquisition and transfer; direct sale of service and/or knowledge by CARTIF. Training programmes.	

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
9	Novel PVT System	Product	WP3	EndeF (O)	TRL7	Patent	4	EndeF

Description: The novel PVT technology from EndeF is based on integrating a PV module with a tubular-structure metal heat collector that uses a di-phasic fluid to transfer heat from the collector. Transferred heat feeds a heat pump and hot water storage.	**Innovation**: The small size PV + heat collector + heat pump system (based on 0.5 m^2 modules) is commercially available. A larger size system based on 2 m^2 modules has been evaluated at lab scale, but issues due to bending of two different materials, PV module (glass) and evaporator (metal) will be explored. In addition, there is low thermal transfer from PV module back sheet to evaporator due to insufficient contact. The evaporator will be improved both with the adhesion tool.
Exploitation Potential: TRL upscaling and direct commercialisation of PVT panels. EndeF is already active into the market and can support the finalisation of the development phase. The company has the ownership of the innovation and aims to promote this solution into the market. An alternative way could be the participation in joint exploitation business as explained in the MiniStor business model deliverable.	

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
10	Water flat plate PVT collectors (Conventional PVT)	Product	WP3	EndeF (O)	TRL7	Patent	3	EndeF

Description: The MiniStor system will be equipped by a PVT panel able to convert, in the same surface, the solar radiation in electricity and thermal energy. EndeF will improve the ECOVOLT and ECOMESH models increasing the energy performance in a cost-efficient way.	**Innovation**: EndeF PVT models will be improved by including a mono-PV laminate and increasing the thermal efficiency by new adhesive between the PV laminate and absorber. First tests have already been carried in EndeF test benches, but final designs and including them in a demo system will be carried out in this project. This project will allow to test the different

					models of PVT panels integrated to the TCM storage under real working conditions.			
Exploitation Potential: The improved hybrid solar collector can be offered and marketed by EndeF in its current customer segments. Furthermore, the system integrated into the MiniStor storage could be commercialized in the facilities currently managed by EndeF.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
11	Strategies for connecting Conventional PVT, with the TCM storage	Knowledge	WP3, WP6	EndeF (O)	TRL7	In this case, EndeF will not implement a specific IP strategy	2	EndeF
Description: Methodologies and strategies for connecting and integrating Water Flat plate PVT panels (Conventional PVT), with the TCM storage designed in MiniStor.					**Innovation**: Currently the connection and integration of PVT panels to the TCM storage have not been analysed under real conditions. In the MiniStor project will be necessary to design and define the connection methodologies and strategies for connecting and integrating this kind of PVT Panel to the innovative TCM storage.			
Exploitation Potential: The PVT system integrated into the MiniStor storage could be commercialized in the facilities currently managed by EndeF. This process generates new knowledge for improve the technician's ability to integrate PVT with storages and can be exploited in O&M consultancy.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
12	Hybrid Energy Storage testing procedures	Knowledge	WP4	EMI (O)	TRL7	N/A	1	EMI
Description: A testing plan will be drafted based on the recommendations from WP2 and WP3, identifying the components and aspects that will be tested. This task will promote the challenges posed by current standards.					**Innovation**: As there is no testing procedure yet for the components and the whole MiniStor system the testing plan could be the first step towards a new testing standard.			
Exploitation Potential: This result will be used in the KER#1 to define the MiniStor Newco knowhow and to integrate the MiniStor solution at building level. The lesson Learnt in this ER will guarantee the respect of the standards and regulations and the system safety.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
13	Thermochemical Unit (TCM)	Product	WP4	CNRS (O) Psycotherm (P)	TRL7	Patent and copyright	4	CNRS

				Sofrigam (P)				
Description: The MiniStor storage capacity will be realised by the thermochemical reaction between ammonia and salt. The heart of the MiniStor solution is a $CaCl_2$-NH_3-based TCM system that is a promising and chemically stable solution allowing multiple usage cycles without degradation of the material and CO_2 impact.					**Innovation**: TCM reactors are representative examples of Thermochemical heat storage (THS) technology, considered as a promising alternative to wide applied sensible (SHS) or latent heat storage systems (LHS), utilizing sorption and/or chemical reactions to generate heat. The system will be based on a Ca_2Cl-NH_3 TCM reactor with improved functionality i.e. in terms of reaction kinetics, thermo-physical and mechanical properties. TCM storage energy density ~12 and 13,5, for heating and cooling respectively, higher than the storage density of water-based systems.		
Exploitation Potential: The TMC units represent the core concept of MiniStor and will be the pillar for the exploitation strategy as MiniStor KER#1 (D7.5). At the same time the ER13 owner CNRS can follow different exploitation models.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
14	Simulation for BESS unit according to PVT electrical production and the electrical load profiles	Model Knowledge	WP3, WP5	EndeF (O)	TRL7	No IP protection	3	EndeF
Description: The simulation model will be developed in a dynamic simulation software. It will allow to analyse the charging and discharging process in the Battery Electrical Storage System (BESS), under different operation modes. The BESS is based on Lithium-ion batteries (available at commercial level) and the model will be used as a tool for a suitable sizing of the BESS according to the PVT electrical production and the electrical load profiles of the MiniStor System and the Building.					**Innovation**: The innovation is based on the definition of the strategies and modes of operation of the BESS based on lithium-ion batteries the new thermal storage system (TCM + PCM) of the MiniStor project.			
Exploitation Potential: Technology licensing, direct production and commercialisation within the ENDEF PVT panels business model.								
#	**ER Name**	**Type**	**WP**	**Owner (O) Partner (P)**	**Final TRL**	**IP Protection**	**Innovation Level**	**ER Manager**
15	MiniStor time and cost-effective construction methods	Knowledge	All	Shared ERs, All (P)	N/A	Eventually copyright	1	IERC

Description:	Innovation:
MiniStor aims to utilize time and cost-effective construction methods, reducing on-site installation time and disruption to occupants, as well as the associated energy-intensiveness of installation from a life-cycle viewpoint. To achieve that, validated innovative installation and construction methods, available to consortium partners will be used, such as mounting methods for TCM and PCM and off-site assembling of prefabricated solutions of TCM and PCM reactors, NH_3 reactor, heat pump and PVT.	A comparable setup would take longer time to be installed and commissioned and would be composed of several sub-systems that need harmonization. MiniStor will develop a harmonized installation system with parts that have been made adequate to function together.
Exploitation Potential: Knowledge transfer or technology licensing.	

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
16	MiniStor footprint impact tool	Software	WP6, WP7	CERTH-CPERI (O)	TRL7	Copyright for LCA & LCC module code and for scientific publications	2	CERTH-CPERI

Description: A tool will be elaborated to calculate the total impact footprint, taking into account not only theoretical aspects, but those that will be Learnt during the demonstration phase. Environmental impact of the integrated system will be calculated both by its expected reduction of primary energy use, and the life cycle of its material components during and after its whole life cycle (cradle-to-cradle approach with economic and environmental aspects). This sustainability toolbox will be built based on SimaPro for the case of residential buildings (new or under renovation) and will cover the main technological components comprising MiniStor. The best option from an environmental and financial perspective can be selected based on this approach. The derived graphical Environmental Performance Strategy Map (EPSM) will allow to combine main environmental indicators (footprints) of each technological solution with its associated cost-benefit indicators.	**Innovation**: LCA/LCC database of material properties based on SimaPro and open-source software for energy-related components will be populated with information on material and assembly methods relevant to PVT panels and TCM salt. New algorithms will facilitate direct calculation of KPIs. This tool will be provided in a GUI open- access environment, increasing use in other environmental assessments.
Exploitation Potential: CERTH/CPERI will leverage MiniStor footprint impact module, developed in SimaPro software, to strengthen its capabilities in the LCA and LCC analysis area. Module will be used internally to enhance the services provided, find new consulting engagements and open new opportunities. Analysis results' will be uptake by other organisations outside the project boundaries. CERTH/CPERI has a strong collaboration with SMEs and industrial partners at National and European level for promoting the scientific achievements to the energy market. Within footprint impact module, CERTH/CPERI	

will collaborate with both single energy prosumers and energy communities, as well as with key stakeholders (SMEs, ESCOs etc) to investigate and use the environmental and cost analysis results. Contacts with PV manufacturers will extend the LCA and LCC databases information in order to accurately extend the module functionalities. Regulators and policy makers could also be included in the exploitation plan as the LCA & LCC analysis expected results will enable the formation of laws to optimize energy use and increase the penetration of renewable sources. Moreover, exploitation potential could be extended to the academic area through publishing the results in well-known and widely read international peer reviewed journals and international and national conferences.

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
17	Circular economy MiniStor Business Model	Knowledge	WP6, WP7	R2M (O) All	N/A	N/A	3	R2M

Description: MiniStor aims at devising cost-sharing BMs capitalizing on 'Ad-hoc collaborative' schemes from a circular economy perspective. The proposed 'portfolio' of BMs that include the MiniStor system will incorporate novel finance and revenue models that will encourage investment in deep energy renovation including low-income building owners or tenants. A BM using the MiniStor system will enrich and advance the 'conventional' BMs of Energy Services Companies (ESCOs) by introducing novel crowdfunding scenarios with renovation stakeholders co-investing in renovation projects.

Innovation: The Circular Economy Business Model collects inputs from the most relevant circularity approach already in place for PV systems, Lithium batteries and ammonia systems to guarantee the best approach in terms of circularity for the MiniStor system.

Exploitation Potential: The ER17 represent the core concept of the MiniStor business model developed in the D7.5. The products and services developed and validated in the project can be used to build a Newco, certified as an ESCo and participated by MiniStor partners as well as by external stakeholder, that operate directly into the market promoting EPC contacts based on energy saving and energy flexibility generated ad building or district level.

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
18	AR/VR interaction with end-users	Knowledge	WP3	CERTH-ITI (O)	TRL7	N/A	1	CERTH-ITI

Description: AR/VR devices will be enhanced to interact with end-users by incorporating machine learning (ML) methods, enabling predictive capabilities. A Living Lab approach will be applied to support co-creation and interaction of envisioned holistic digital system with relevant stakeholders, encouraging user feedback.

Innovation: The platform is already equipped with visual analytics and advanced visualizations, which in conjunction with machine-learning techniques will provide enhanced information to stakeholders enabling predictive capabilities and better guidance to users. These techniques are expected to support the entire analytics pipeline from data acquisition through data cleaning and selection, to visualization of model outputs.

	Multi-user and near-real-time modelling that incorporate ergonomics and high level of detail (LoD) capturing ability, new-generation algorithms (e.g. Hololens technology) will be developed and applied. These include voice control with lingual analysis, gesture control and speech synthesis, enhancing effectiveness for 360-degree area scanning. These new capturing techniques will add interesting, sophisticated functionalities related to identifying component connections, hazardous materials (e.g. NH_3) and components for recycling.
Exploitation Potential: The tool possibilities will be extended beyond manufacturing areas to tackle the field of installation processes through interactive training and guidance of workers. The tools strength is that it transforms traditional work instructions into smart instructions and users are immersed into animated, intuitive, 3D computer generated imagery that overlay on top of the real world.	

#	ER Name	Type	WP	Owner (O) Partner (P)	Final TRL	IP Protection	Innovation Level	ER Manager
19	Methodology for MiniStor O&M	Knowledge	WP2, WP7	HSLU (O) All	TRL7	Open source	1	HSLU

Description: This ER is the method for a safe system operation under the expected residential usage conditions, as well as in its assembly and shipment stage.	**Innovation**: As far as we know, ammonia has never been used for residential purposes. Therefore, the transport of ammonia to the site, the installation of the entire system at the site and the conditions for the use of ammonia in a residential environment require new/novel procedures. The safety of the people in their homes is the top priority, therefore we will define all the above-mentioned points: safe transport, safe installation and safe conditions of use of the MiniStor system in residential areas.
Exploitation Potential: The knowledge learnt in the project will produce the O&M guideline for the correct use and maintenance of the MiniStor system: This output will be included in the deliverable 7.9 that can be disseminated as exploitation strategy. At the same time this result will participate in the KER#1 representing an important joint knowledge for the MiniStor Newco.	

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

3. MiniStor Key Exploitable Result definition

The second phase of MiniStor exploitation activity focussed on the definition of the MiniStor Key Exploitable Results (KERs). The following chapters explain the methodologies used in this assessment and outline the result obtained.

3.1 Selection Criteria and Methodology

From the literature, a KER can be considered as *"a commercial-ready ER which has been selected and prioritised due to its high potential to be "exploited" – meaning to make use and derive benefits downstream the value chain of a product, process or solution, or act as an important input to policy, further research, or education"* [4].

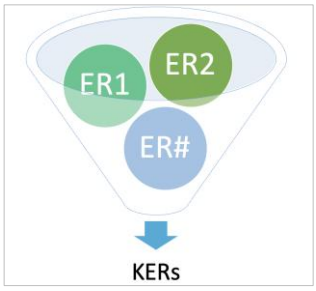

Figure 5. KERs selection

Taking in consideration the final ER table, presented in the Table 2, the identification of KERs has been done by the application of three quantitative criteria and one quantitative criterion. In addition to the selection criteria, the exploitation strategy used an additional methodology to assess the ERs marketability: the risks and impact assessment applicated.

Quantitative Criteria:

1. **Final TRL at the end of the MiniStor**: This criterion refers to the TRL level[5] already described in D7.4 on page 6. The TRL of the ER has been updated regularly to track any kind of deviation from the planned final TRL. The threshold for this criterion has been set at level 6 which represents a "prototype system verified", as shown in the Figure 6. It is important to note that all the ERs analysed in MiniStor reached the final TRL of 7, positioning over the threshold.
2. **Final Innovation level of ER**: The Innovation Level[6] refers to the Triz theory described in the D7.4 at page 7 and shown in the Figure 7. The threshold for this criterion has been set at 3 which represent an Innovation compared to existing solution on the market.
3. **Protectable Intellectual Property**: Related Intellectual

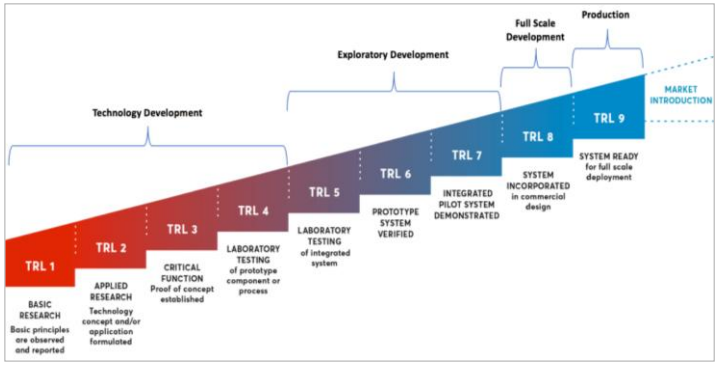

Figure 6. TRL levels

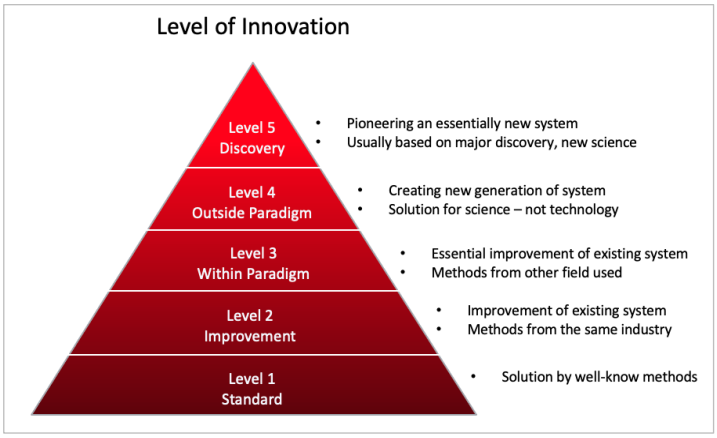

Figure 7. Innovation levels (Triz theory)

[4] Horizon Result Platform: https://intellectual-property-helpdesk.ec.europa.eu/system/files/2022-02/HEU%20Results%20platform.pdf
[5] https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf
[6] Source: Wikipedia - https://en.wikipedia.org/wiki/TRIZ

Property Right (IPR) should be protectable (e.g., if the ER is software, the methodology can be considered as IP). The threshold is "Yes, the ER is protectable".

Qualitative Criteria:

The qualitative criteria define the replicability in different business models and context:

4. Application at pilot site (i.e. applicability in different country and different contexts). This criterion is important for the replication plan and the market penetration of the MiniStor business model because it make in evidence potential bottlenecks. Therefore, it is fundamental that all the KERs have been assessed in different pilot sites. The threshold is "Yes, it is replicable"

3.2 Risk and Impact assessment

This analysis, based on two dimensions, aims to investigate the level of risk and impact for the Exploitable Results with the expectation to maintain low the exploitation risks and improve the innovation level. This process enables the project to target exploitation activity in the most efficient way. This procedure is based on the data collection templates and a graphical output that maps each ER in a plane with expected impact on the y-axis and innovation risk on the x-axis.

The scope of this assessment framework is the identification and the selection of ERs with those dimensions:

- Expected impact: it should be as high as possible.
- Innovation risk: it should be as low as possible.

The representation on a two-dimension graph consisting in four quadrants (categories) as illustrated by Figure 8:

- A "Niche opportunity" is an ER with low expected impact and high innovation risk.
- A "Promising concept" is an ER with high expected impact and high innovation risk.
- A "Safe Play" is an ER with low expected impact and low innovation risk.
- A "Rising Star" is an ER with high expected impact and low innovation risk.
- Key Exploitable Results shall be those in the "Rising Star" quadrant.

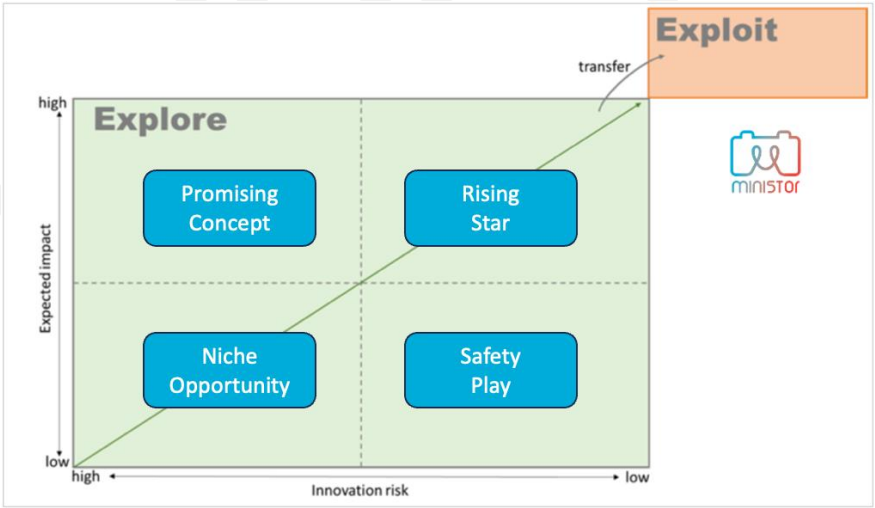

Figure 8. Risks and Impact assessment exploitation board

Literature research shows that 80% of innovations is on the bottom-left quadrant, 15% is somewhere in the middle and only 5% make it to the top-right quadrant. The data at the basis of this analysis are collected from the ER managers (ER owners in principle) by a questionnaire reported in the chapter 3.2.1. This process, apart for the assessment of the KERs, aims to identify ER with some criticism that can be solved during the project by correction measures. This is the case of ERs with high risks rate where mitigation measures could facilitate market acceptance. Each of these two dimensions is assessed according to several indicators, as follows:

Expected impact indicators:

- Economic impact indicators

- Size of the untapped market
- Type of addressable market
- Market need
- Market growth
- Scalability of the business model

- Environmental impact indicators
  - Carbon footprint reduction
- Societal impact indicators
  - Social inclusion

Innovation risk indicators:

- IP protection
- Type of innovation
- Alternative solutions
- Completeness of technology
- Regulatory hurdles
- Additional development needed
- Management support
- ER ownership

3.2.1 Risks and Impact data collection template

This sub chapter describe the template, and the methodology used for the evaluation of the risk and impact assessment. The data collected represent indicators for the identification of risks and impacts of ERs associated to economic, societal and environmental factors. The indicators are based on a ranking from 1 to 5 representing the evidence of the indicator.

1) Indicator: The indicators are the variables used for measuring the expected impact and innovation risk. For each project a set of indicators need to be defined to do justice to the specifics of the business domain and developed foreground.
2) Value: Describes the score of the value of the indicator. The way indicators are scored, differs per indicator but in general indicators score in a spectrum with two extremes, e.g., small-large, weak-strong, low-high etc.
3) Evidence: Evidence is used to support the underlying hypothesis of the ER indicator. The strength of a piece of evidence determines how reliably the evidence helps to support or to refute a hypothesis. Here some examples of weak and strong(er) evidence [7] reported in the Table 3 and Table 4.

Table 3. Example of indicators assessment

Weak evidence	Strong(er) evidence
Opinions (beliefs)	Facts (events)
What people say	What people do
Lab setting	Real world setting
Small investments: signing up by emails to show interest in an upcoming product or service is a small investment	Large investments: Pre-purchasing a product or a service or putting one's professional reputation on the line is an important investment

Table 4. Example of evidence scoring

Score	Evidence
Weak (1)	One man's opinion

[7] Bland D. and Osterwalder A., (2020) Testing Business Ideas

Poor (2)	What people say
Moderate (3)	Lab setting, small investments: signing up by emails to show interest in an upcoming product or service is a small investment
Fair (4)	Facts, market report, what people do
Strong (5)	Large investments: Pre-purchasing a product or a service or putting one's professional reputation on the line is an important investment

Table 5. Section A: Expected impact (economic, societal and environmental) of the ER

Indicator	Value	Evidence (Strength)
Economic impact		Score
Size of the untapped market	Small - Large	1 – 2 – 3 – 4 – 5
Type of addressable market	Existing - New	1 – 2 – 3 – 4 – 5
Market need	Not clear - Clear	1 – 2 – 3 – 4 – 5
Market growth	Low - High	1 – 2 – 3 – 4 – 5
Scalability of the business model	Poor - Very good	1 – 2 – 3 – 4 – 5
Environmental impact		
Carbon footprint reduction	Small - Large	1 – 2 – 3 – 4 – 5
Reduction of local pollution	Small - Large	1 – 2 – 3 – 4 – 5
Impact on circular economy	Low - High	1 – 2 – 3 – 4 – 5
Societal impact		
Social exclusion	None - Reduced	1 – 2 – 3 – 4 – 5
Energy poverty	None - Reduce	1 – 2 – 3 – 4 – 5
Stimulation of citizens' involvement in policy making	Low - High	1 – 2 – 3 – 4 – 5

Table 6. Section B: Innovation risk of the ER

Indicator	Value	Evidence (Strength)
IP protection	Weak - Strong	1 – 2 – 3 – 4 – 5
Type of innovation	Incremental - Adjacent - Transformational	1 – 2 – 3 – 4 – 5
Alternative solutions	Better alternatives - No alternatives	1 – 2 – 3 – 4 – 5
Completeness of technology	TRL1 - TRL9	1 – 2 – 3 – 4 – 5
Regulatory hurdles	Yes - No	1 – 2 – 3 – 4 – 5
Additional development needed	Major - None	1 – 2 – 3 – 4 – 5
Management support	None - Committed	1 – 2 – 3 – 4 – 5
ER ownership	None - Clear	1– 2 – 3 – 4 – 5

Each ER manager provided an evaluation on the indicators listed in the Table 5 and Table 6 for the ERs owned and managed. The data collected have been reported in the risks and impact exploitation board with the graphical result presented in the Figure 9.

In the graph, the ERs are positioned in different zones representing the different exploitation conditions presented at the beginning of this chapter. To have a more compressible positioning of the ERs, respect to the thresholds selected for risks and impacts, the Figure 9 use shifted scales for the axis. Even if this visualisation method could create mismatching with the quadrants from Figure 8, it doesn't change the classification of ERs on their relative order.

It is possible to identify four groups of ERs that in the graph are represented by the green, yellow, cyan and red colour. In the green group follow ERs defined as "Rising Star

3.2.2 Risks and Impact assessment results

The Risks and Impact assessment applied to the MiniStor ERs is shown in the Figure 9. In reference to the four categories of presented in the Figure 8, here the most populated is the "Rising Star" with eight ERs as confirmation of the hight innovation aspect of the MiniStor project.

Six ERs are identified as "Niche opportunity" because their low expected impact rate respect to the other results. Only two ERs (ER14 and ER17) are identified as "Promising Concepts".

Three ERs are placed in the middle of the table as "Safe Play".

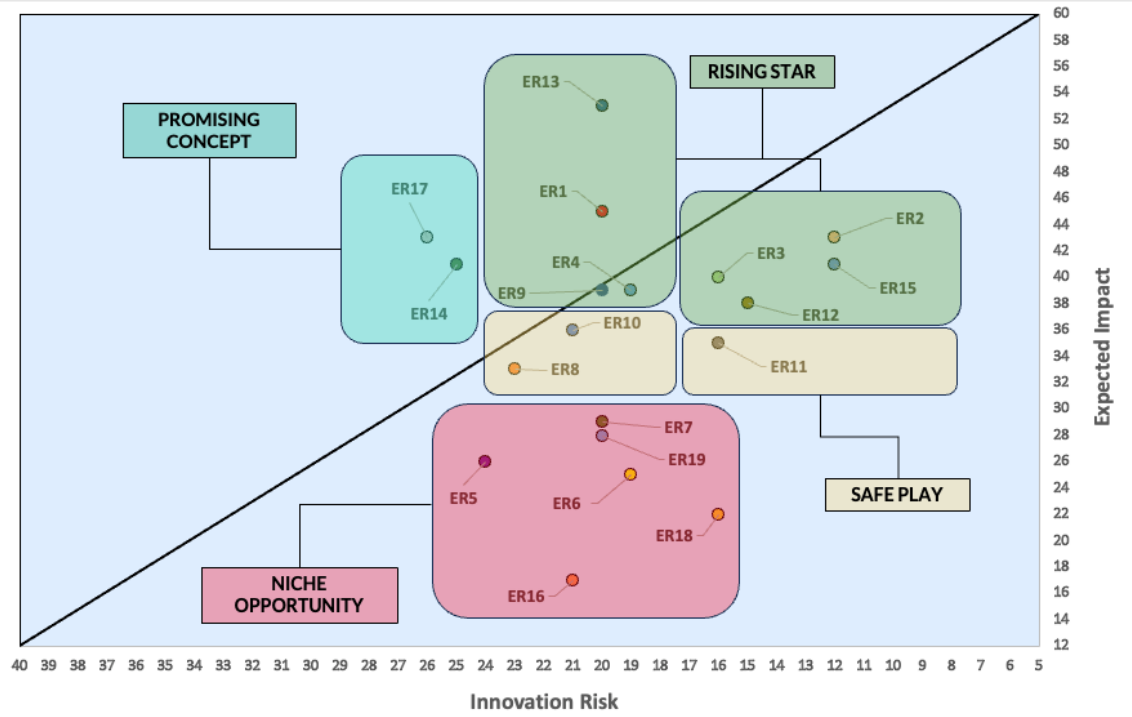

Figure 9. MiniStor ER risks and impact mapping

The thresholds defined for the risk level (22) and for the impact assessment (35) has been set considering the relative ER distribution respect to the average value and to define a group of ERs with relevant characteristics for an easier the replicability respect to the others.
The entire result of the risk and impact assessment is included in this report as Annex I. This result is integrated in the KERs definition metric (Table 7) and participates in the KERs definition as a criterion of choice.

3.3 Key Exploitable Results Selection

Table 7. Summary of criteria for MiniStor KERs definition

#	Exploitable Result	Type	TRL (Threshold 6)	Innovation Level (Threshold 3)	Protectable	Application at pilot site	Impact level (Threshold higher than 35)	Exploitation risk (Threshold lower than 22)	KER
1	MiniStor compact energy Storage	Product	7	4	YES	YES	45	20	KER#1
2	Software model to implement the system in state-of-the-art whole-building energy modelling programs	Model	7	2	YES	NO	43	12	NO
3	Home Energy Management System (HEMS)	Product	7	3	YES	YES	40	16	KER#2
4	Visual interface IoT-platform for user interaction	Software	7	3	YES	YES	39	19	KER#5
5	Enhanced Energy Modellers (DR forecasting and optimization tool)	Software	7	2	YES	YES	26	24	NO
6	Cloud base monitoring Tool and data mine	Software	7	1	YES	YES	25	19	NO
7	HEMS - High level control	Knowledge	7	2	YES	YES	29	20	NO
8	Distributed Energy Resource prediction model	Model	7	2	YES	YES	33	23	NO
9	Novel PVT System	Product	7	4	YES	NO	39	20	KER#3

10	Water flat plate PVT collectors (Conventional PVT)	Product	7	3	YES	NO	36	21	NO
11	Strategies for connecting Conventional PVT, with the TCM storage	Knowledge	7	2	NO	NO	35	16	NO
12	Hybrid Energy Storage testing procedures	Knowledge	N.A.	2	NO	YES	38	15	NO
13	Thermochemical Unit (TCM)	Product	7	4	YES	YES	53	20	KER#4
14	Strategies for integration of BESS Unit with TES	Knowledge	N.A.	3	NO	NO	41	25	NO
15	MiniStor time and cost-effective construction methods	Knowledge	N.A.	1	YES	YES	41	12	NO
16	MiniStor footprint impact tool	Software	N.A.	2	YES	YES	17	21	NO
17	Circular economy MiniStor Business Model	Knowledge	7	2	NO	YES	43	26	NO
18	AR/VR interaction with end-users	Knowledge	N.A.	1	NO	NO	22	16	NO
19	Methodology for MiniStor O&M	Knowledge	N.A.	1	NO	YES	28	20	NO

The Table 7 shown the ranking of the selection criteria applied to the ERs. The colours have been used to show the ranking obtained respect to the selected thresholds for each criterion. The green colour represents a situation where the ER overcomes the threshold, the red colour represents a threshold not reached and the yellow colour a situation where the ranking is very close to the threshold. Identification with yellow colour means that, with a minor improvement, the ERs could reach an improved level in the classification. The final KERs list is reported below in the Table 8.

Table 8. Final KERs table

KER#	KER Name	Owner	Type	Partners
KER1	MiniStor Compact Energy Storage System	Joint Ownership	Product	MiniStor consortium
KER2	Home Energy Management System (HEMS)	CARTIF	Product	CERTH-ITI; HSLU
KER3	Novel PVT System	ENDEF	Product	-
KER4	Thermochemical Unit (TCM)	CNRS	Product	Psyctotherm, Sofrigam
KER5	Visual interface IoT-platform for user interaction	CERTH-ITI	Software	-

The output from the KERs selection feed directly the MiniStor business model task where for each KER a detailed business model has been drafted (deliverable 7.5).

3.4 KERs BOSAT assessment

Following the characterisation of the KERs, they were analysed using the BOSAT methodology and tool. This investigation identified areas where the KERs require further deep development and analysis to guarantee the TRL upscaling and to produce a business plan for their market entry.

This procedure has been applied only to the KERs list because from the KERs selection, the focus of the exploitation activity is moved on them.

The BOSAT tool and its methodology are results implemented in the Business Opportunity Support System that is "*… an open, multilingual and web-based platform designed to stimulate students', researchers' and teachers' ability to use the results of their research and to start and carry out entrepreneurial projects*" developed into the Business Opportunity Support System upgrade for strengthening European innovation ecosystem project (BOSS)[8], co-funded by the Erasmus + Programme of the European Union. The BOSS project developed the BOSAT tool – "Business Opportunity Self-Assessment Tool".

This activity has been carried out in the last period of the MiniStor project to consider the final status of each KER. Each KER manager filled the BOSAT template, here reported in the Annex III, about the six different areas of investigation:

1. Technology: This aspect takes in consideration any development of the technical solution, the scientific and technology research done in the project. A good rating (4 or 5) represents a low level of additional research needed after the project.
2. Unique value proposition: The unique value proposition if identify the added value of the products, goods or services developed in the project, respect to the market and the customers which need those results. A good positioning here represents a well value chain already identified into the project.
3. Team: This aspect takes in consideration the resources (partner's competencies and skills) needed to implement the result and bring it into the market. A good rating in this parameter

[8] Source: https://bossplatform.rect.bg.ac.rs/

means that the team is completed to provide a TRL upscaling and replicability without additional partners. This aspect is strongly connected with the business modelling phase in the exploitation roadmap.

4. Market: This aspect identifies the results of the market analysis and the identification of the type of market where the result aims to enter and penetrate. A good rating here means that the market is well known in its characteristics.
5. Financial aspects: The financial aspects take in consideration the economic (financial) resources necessary to implement the result and bring it at TRL9. A bad rating in this point represents a situation where there are few resources for the TRL upscaling and probably the replicability will be blocked without additional financial resources.
6. Innovation property: The innovation property is another aspect connected with the market analysis and business modelling. It considers the innovativeness of the result against the market competitors. The classification of this parameter comes firstly from knowledge collected by the KER owner and supported by the MiniStor market analysis (deliverable D7.6).

The BOSAT questionnaire is composed by 59 questions divided in six areas, in which the compilator must choose a predefined response from a list of replies.

By an algorithm based on the selected replies, the tool produces an assessment on the six areas in a graduate scale from zero to five, where 5 means the best assessment and zero lacks information or not an assessment not sufficiently developed.

The result of the mapping process is to identify the development areas where the key exploitable results (called 'Business Opportunity' in the questionnaire) have a good level of analysis (rating 4/5) or lack one (rating lower than 3). In this way, the owner must focus their attention on the areas where deficiencies have been identified to guarantee TRL upscaling and replicability of the results.

3.4.1 KER#1 MiniStor Compact Energy Storage System - BOSAT

The results of the BOSAT analysis applied to the KER#1, illustrated in the radar in Figure 10, shows a key strength in defining the Unique Value Proposition, scored (4/5), backed by the solid Technological foundation (value 4.4/5), which underpin the innovative MiniStor Compact Energy Storage System solution as a key technology for the thermal energy storage, respect to the current solutions.

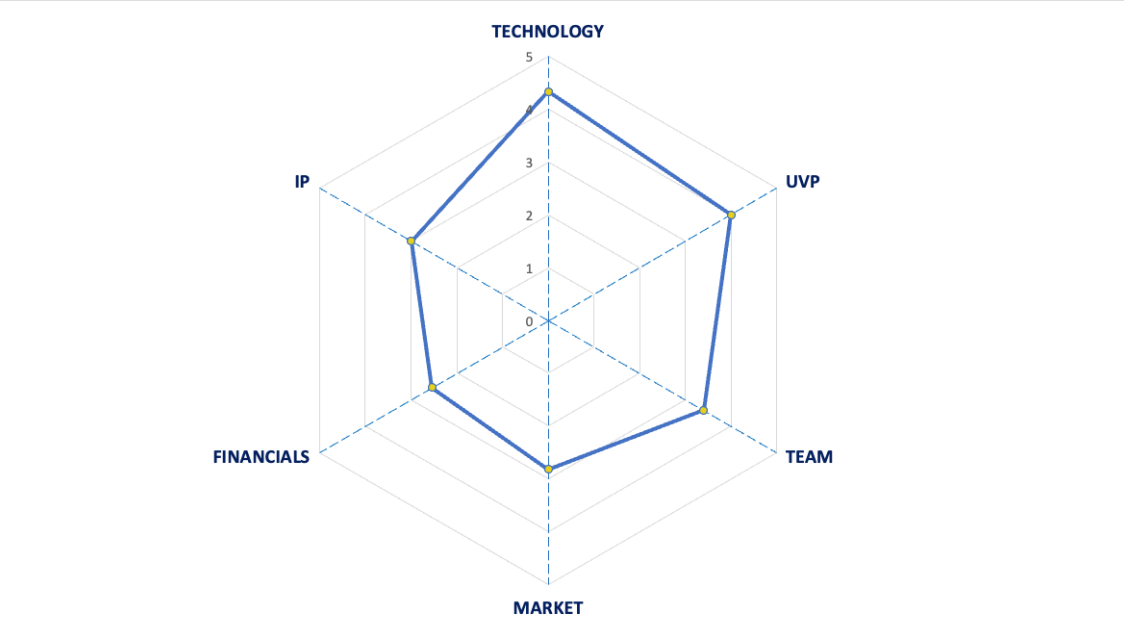

Figure 10. MiniStor Compact energy Storage System BOSAT radar mapping

The system demonstrates a disruptive value proposition, with the potential to significantly transform its target market. Validation has already been achieved under real operational conditions in different climatic conditions, confirming TRL 7. The added value of the system is both qualitatively (completely zero emissions) and quantitatively measurable (about 10 time the capacity of water base thermal storages), and the benefits are clearly understandable and communicable across various stakeholder groups, enhancing its market attractiveness.

The implementation Team received a respectable score of 4.0, reflecting a strong organizational structure and significant project management experience. Roles and development procedures are clearly defined, contributing to efficient collaboration and workflow. The team is largely complete, composed of a mix of consortium partners and external collaborators, which ensures access to a broad range of expertise, from technological optimization to strategic planning for market scaling. This collaborative approach enhances the project's capacity to transition smoothly from pilot testing to full-scale deployment. The team could be completed by the addition of partners with recircling expertise to close the whole circular economy approach at the base of its business model.

The Market readiness of the technology was assessed with a moderate score of 3.0 out of 5. While the system shows substantial potential to make a meaningful impact in the energy storage sector, some regulatory challenges, particularly concerning the use of ammonia, pose barriers to broader market adoption. These issues need to be addressed to fully unlock the commercial potential of the technology investigated in the MiniStor project only for the residential sector.

Regarding the IP aspect, a score of 3.0 was assigned. Initial steps have been taken to secure IP rights for key aspects of the system; however, no novelty search or comprehensive IP risk analysis has yet been performed. The Financial dimension received a score of 2.7/5, reflecting the early-stage nature of the commercialization process. This rating is consistent with the TRL 7 status, which, while indicative of technical maturity, still requires substantial financial planning and investor engagement to move towards industrialization and market entry. To support the next steps, it is crucial to clearly define funding needs, develop a detailed financial roadmap, and begin actively seeking investment partners who can enable scaling and commercialization

3.4.2 KER#2 Home energy Management System – BOSAT

The BOSAT analysis, illustrated in Figure 11 by the radar map, confirms that the HEMS developed by CARTIF (KER2) project's development status at TRL 7, indicating that a prototype has been demonstrated in an operational environment.

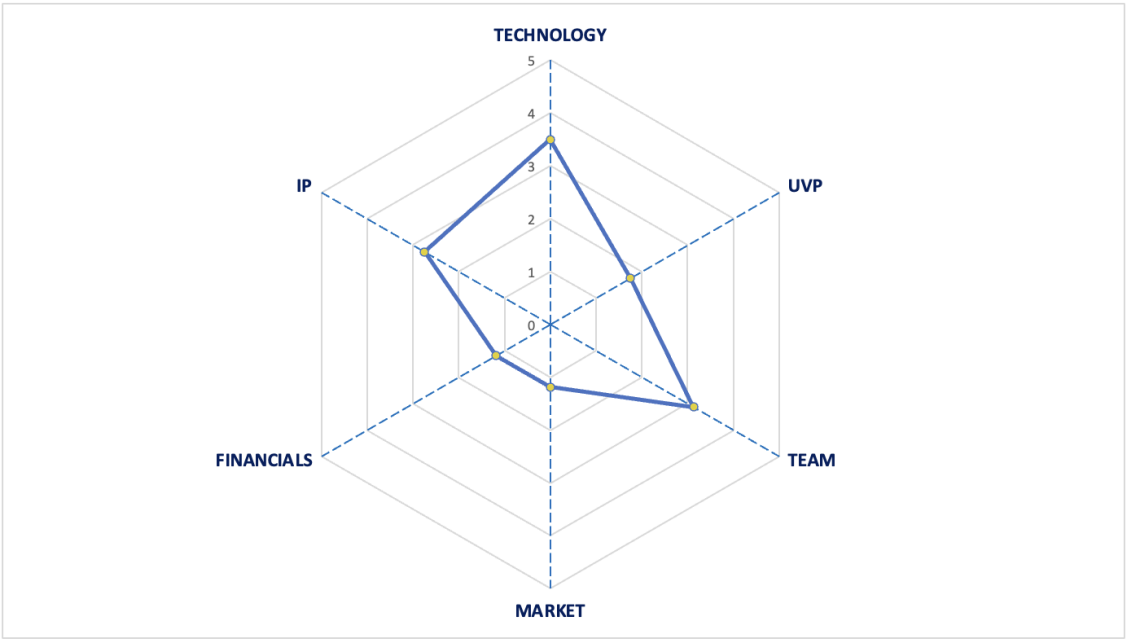

Figure 11. Home Energy Management System BOSAT radar mapping

This maturity is supported by a moderate Technology development score of 3.5 out of 5, confirming that key technical components have been validated in relevant settings. However, the technology has not yet evolved into a fully deployable, market-ready solution (TRL9) as well as the rest of the MiniStor system.

This limitation is reflected in the low scores for the Unique Value Proposition (2/5). The low score in the Unique Value proposition represents the market situation where there a several competitors, already into the market, with a detailed customer segment characterisation. The MiniStor HEMS can be easily adapter to other systems and customer segments because it is still at TRL7.

For the same reasons also the Market potential score is low about (1.8/5). The EMS market is growth very fast in the last years and is now populated by different and skilled competitor systems. Although the HEMS shows promise for advancing the SoA, its concrete business model impact and broader market adoption has yet to be validated, by integrating added values within the value chain.

The implementation Team received a score of 3.3/5, indicating a solid level of managerial and operational expertise. This capability is expected to play a critical role in driving the project forward and facilitating the progression to higher TRLs. Nevertheless, the product faces significant challenges in its Financial dimension, as shown by a low financial readiness score of 1.5/5. This reflects the absence of a financial plan and a structured engagement with potential investors and a lack of defined strategies for funding the next stages of development, including commercialization and scaling. This is quite aligned with the level of the Value proposition and the Market Potential.

IP management has been rated at 3/5, mostly attributed to the open-source exploitation strategy. Despite the lack of patents, some level of IP protection is being implemented through confidentiality measures and strategic considerations aligned with the initial and future target markets.

In summary, while the HEMS exhibits strong technological progress and an experienced implementation team, there is a notable gap in its financial and market readiness. Addressing these aspects—particularly by strengthening the business model, engaging with investors, and clarifying the unique value proposition—will be crucial to transitioning from a validated prototype to a competitive market solution.

3.4.3 KER#3 Novel PVT System – BOSAT

The BOSAT analysis, as illustrated in Figure 12 through the radar map, highlights a strong and well-structured Technology development (scoring 4.1/5), supported by a capable and well-organized development Team, which received a score of 4.0 that reflects the ownership of EndeF and the internal development with the commercialisation purpose.

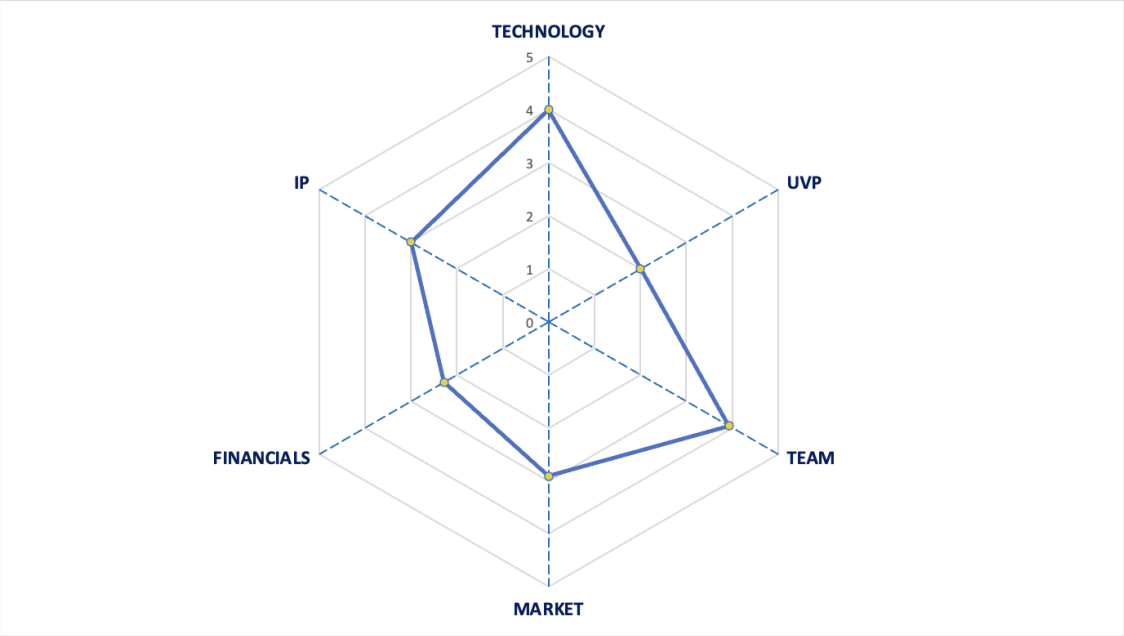

Figure 12. Novel PVT System BOSAT radar mapping

The technology has been tested directly with potential early adopters in a real operational environment, receiving positive feedback. It aligns with its current TRL 7 status, confirming the technology's readiness for pre-commercial deployment. The team's structure, with clearly defined roles and competencies, demonstrates the necessary technical and managerial capacity to optimize the product and successfully guide it through the scale-up phase.

In the Market readiness dimension, the analysis assigns a score of 3.0. While the target customer needs have been effectively identified and the PVT solution was validated in the residential segment, actual contact with potential new customers has not yet occurred. Nonetheless, there is a clear vision for the market launch, supported by a preliminary sales and marketing strategy. To move forward, active engagement with these identified customers is essential to build initial demand and foster early market traction. A strong marketing campaign supported by a detailed competitor's comparative assessment could facilitate the market penetration.

A significant weakness emerges in the Financial readiness area, which scored 2.3. While a sound exploitation strategy is in place, the scale-up effort lacks concrete financial planning. There is currently no detailed funding strategy, and outreach to potential investors has yet to begin.

IPR management received a moderate score of 3.0, indicating that a basic protection strategy has been developed. Some intellectual property rights have been considered, with at least one potentially in use. However, a more comprehensive and actionable IP strategy will be needed to safeguard innovation during market expansion.

A critical area for improvement is the Value Proposition, which received a score of 2.5. Although it has been identified and the added value to customers conceptually and qualitatively validated, it is crucial to quantify the benefits and test them directly with potential clients, respect to the competitors already present into the market.

3.4.4 KER#4 TCM Units – BOSAT

The BOSAT analysis, as illustrated in Figure 13 by the radar chart, provides a comprehensive evaluation of the TCM Storage System.

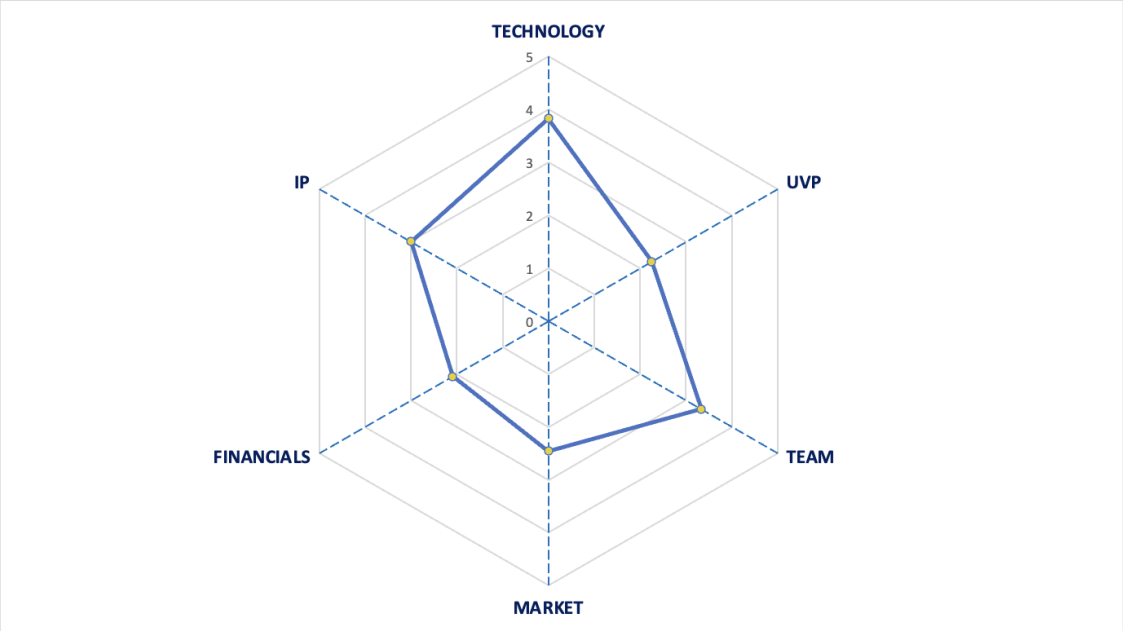

Figure 13. TCM Unit BOSAT radar mapping

The system offers a strong and clear Unique Value Proposition, scoring 3.6 out of 5, backed by solid Technological development efforts, which scored 4.0 out of 5. Together, these strengths provide a solid basis for improving the current SoA for the TCM solution applied to the thermal storage systems. The value proposition has been validated in operational settings, confirming the system's TRL at 7. This indicates that the technology is both effective and mature, although not yet fully integrated into a commercial value chain. Notably, the TCM system offers distinctive advantages

that are difficult to replicate (thermal capacity about 10 times then the water based thermal storage systems), with measurable quantitative benefits.

However, full integration into the Market ecosystem remains a challenge at this stage. The market dimension, indeed, received a relatively modest score of 2.5/5, reflecting the dual nature of the technology's potential. On one hand, the TCM system, developed by CRNS, holds substantial promise due to the considerable benefits it offers to its target user base. On the other hand, market penetration is hampered by regulatory uncertainties and a high risk of resistance, primarily because the system relies on ammonia-based reactions. Although efficient, this approach introduces limitations in terms of operational scalability and safety compliance, which could hinder broader adoption in the residential application.

The implementation Team scored 3.3 out of 5, reflecting a structured group with defined roles and established development procedures. The team has identified the necessary competencies for future scaling efforts. However, a significant gap remains in terms of commercialization experience, particularly in engaging with stakeholders, navigating market dynamics, and driving adoption. Bridging this gap is essential for the project to transition from development to market readiness.

The Financial aspect received the lowest rating, at 2.2 out of 5, underscoring an area in need of significant attention. Currently, there is no comprehensive financial plan in place for market scale up and no efforts have yet been taken to attract investors or secure funding.

Lastly, the IP strategy scored 3.0/5, indicating a foundational level of protection. A focused strategy has been developed to safeguard one of the key components of the business offering, with consideration given to both current positioning and future customer targets. This is a positive start that moves the TCM unit closer to market deployment.

3.4.5 KER#5 Visual interface IoT-platform for user interaction – BOSAT

The results of the BOSAT analysis applied to the KER#5, illustrated in the Figure 14, reveal several key insights into the current development status of the business objective.

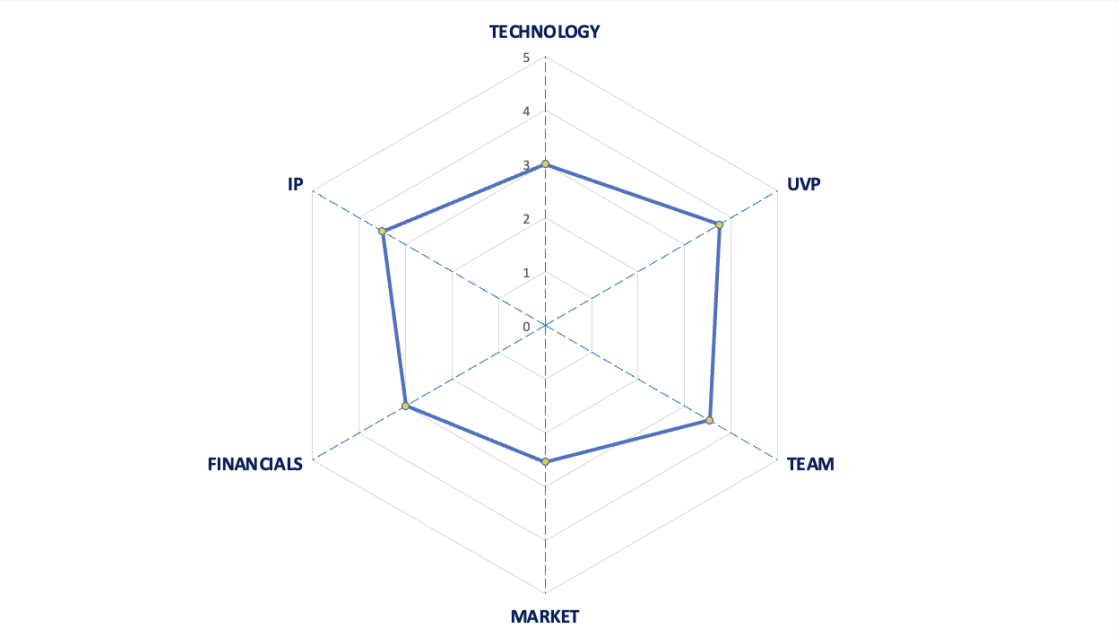

Figure 14. Visual IoT-platform for user Interaction BOSAT radar mapping

A particular strength was noted in the identification of the Unique Value Proposition, which received a score of 3.8 out of 5. This indicates that the value proposition has been clearly defined and assessed both. However, it has not yet been directly validated with potential clients, which aligns with the project's current TRL 7 statuses, where technological validation is achieved, but full market engagement remains pending.

The Technology section scored 3/5. The solution demonstrates tangible improvements over existing technologies and has been validated in a real operational environment, contributing to an advancement over the current SoA, but it has not totally completed its process. Nevertheless, the presence of readily available substitute products and the risk of replication by competing R&D centers limit the perceived uniqueness and defensibility of the technology.

IP management achieved a solid score of 3.5/5. This reflects the development of a targeted protection strategy focused on safeguarding key components of the business objective, particularly regarding current and future target customers. Although copyright, even if they are in the owner plant, have not been filed, a thoughtful approach to confidentiality and competitive positioning is in place.

In the Market section, which scored 2.6/5, the CERTH-ITI IoT Platform identified the needs of its target customers, however without validating them. On a positive note, potential early adopters have already been identified and initial contacts with some of them have been established, suggesting a promising path forward.

The Financial section achieved a score of 3/5, reflecting a well-defined exploitation strategy. Development, industrialization, and market launch costs have been considered, providing a foundation for commercialization. However, further progress is needed in securing the necessary financial resources. Approaching potential investors will be essential to support the scaling and market entry of the technology.

Finally, the Implementation Team received a score of 3.5/5, indicating a well-structured group with clear role allocation. The team has identified the core skills required for upscaling the project. Nonetheless, a critical gap remains in marketing and sales capabilities, which must be addressed to ensure effective commercialization and customer engagement.

3.4.6 BOSAT assessment final consideration

Finally, from the Table 9, it is possible to see that all the KER technological assessment received a good ranking, which is the result of research and development activities. The analysis of the Unique Value Proposition indicates a lack of focus on KER#2 and KER#3, suggesting that the relevant business segment is still not clearly defined. All the KERs identified a high level of teamwork, a consequence of the effective composition of the consortium. The market identified some shortcomings for KER#2 and KER#5 due to the large number of market competitors, and for KER#4, where the situation is the opposite due to the niche market.

Table 9. BOSAT summary table

KER	Technology	Unique Value Proposition	Team	Market	Financial	IP
MiniStor Compact ESS	4.4	4	4	3	2.7	3
Home Energy Management System (HEMS)	3.5	2	3.3	1.8	1.5	3.5
Novel PVT System	4.1	2.5	3	3	2.3	3
Thermochemical Unit (TCM)	4	3.6	3.3	2.5	2.2	3
Visual interface IoT-platform for user interaction	3	3.8	3.5	2.6	3	3.5

The financial aspect of the KERs it seems to be the most poorly evaluated, but it is quite common in a TRL7 research project where the financial development and the business plan of the results is often planned.

4. Partners Replication Plan

The replicability of the MiniStor knowledge and results is driven by the strategic vision and business planning of each of the partners involved in the project development.
The table below shows the lessons learnt by the partners and their own replication plan exploitation and reuse of the innovation generated within MiniStor.

Table 10. Replication Plant table

Partners Replication Plan	
IERC	**Lessons Learnt and knowledge improvement:** IERC, as collaborative research centre in field of integrated sustainable energy systems, aims to improve develop solutions and innovative services to meet global societal needs for secure, affordable and sustainable energy services. One of the main challenges is the reduction of real energy demand. In MiniStor IERC works as project coordinator ensuring the collaboration between the consortia. The lessons Learnt participating in the MiniStor project are divided between: - An improved in-depth the knowledge on factors affecting development and performance of thermal energy storages. This will help in the development of new and more accurate representation models for energy saving estimations. - An improved and more accurate knowledge on the factors affecting scalability of thermal energy storage deployments in Europe, and the regulatory framework for their development. This can help in the work done by IERC for policy recommendations and estimations for future energy scenarios.
	Replication Plan: IERC participated in the development of two ERs, the ER#2 as owner and the ER#15 as partner in collaboration with rest of the consortium. - ER#2 (O): Model to implement the system in state-of-the-art whole-building energy modelling programs: This result will used after the project end as base code and its methodology as backbone for representing similar systems in other programs and extending it as a plugin to programs with visual representation such as BIM (e.g. Revit). - ER#15 (P): MiniStor time and cost-effective construction methods: Use of the experiences gained during prototype planning and installation to improve timelines for novel systems in construction and for development of new technologies by considering factors such as definition of regulatory requirements, delays by providers, malfunction of different components. Definition of streamlined methods to install small-scale thermal and electrical energy storage systems.
CERTH-CPERI	**Lessons Learnt and knowledge improvement:** CERTH is one of the largest Research Centre in Greece. Their participation in MiniStor involves the Chemical Processes & Energy Resource Institute. Participation in the MiniStor project has significantly enhanced CERTH-CPERI's expertise in several key domains related to the development, evaluation, and replication of innovative Thermochemical material (TCM) storage systems for residential applications. Through the initial thermal and electrical system modelling activities (Deliverable D3.1), CERTH-CPERI advanced their capabilities in system simulation using integrated platforms like Aspen Plus Dynamics and MATLAB-Simulink. These models enabled the detailed assessment of the performance of each component (e.g., thermochemical reactor, ammonia cycle, heat pump, phase-change materials, photovoltaic-thermal panels) and evaluated their contribution to meeting heating and cooling demands across demonstration sites.

	Additionally, the preparatory work on site-specific installation activities and compliance analysis (Deliverable 6.3) enriched the CERTH-CPERI's understanding of practical implementation challenges, including integration with existing HVAC systems, obtaining licenses for ammonia-containing equipment, and ensuring compliance with standards like EN-378 (key standard previously analysed). This work also provided valuable experience in bridging technical design with regulatory frameworks. As co-responsible for the Thessaloniki pre-pilot demonstration site, CERTH-CPERI acquired valuable hands-on experience in the practical challenges of deploying an integrated energy storage system. This included the tendering, installation, and commissioning processes. Lessons Learnt included the importance of advance planning for tendering and licensing, careful consideration of site logistics (e.g., crane use for heavy equipment placement), integration of fire and leak safety measures, and practical issues encountered during the hydraulic and electrical connection phases. Real-world operational insights such as pressure management, protection of solar fields against overheating, and PLC emergency commands were gained and documented to facilitate smoother installations in the demo sites. Also, through the feasibility study for replication across Europe (Deliverable 6.7), we deepened our knowledge on evaluating technical potential, identifying legislative and logistical barriers, and developing practical recommendations for successful system replication under varying climatic and regulatory conditions. From the environmental assessment activities (Deliverable 7.3), we strengthened our skills in life cycle assessment (LCA) and life cycle costing (LCC) through the development and application of the MiniStor Footprint Impact Tool. We gained deeper knowledge in quantifying environmental impacts across 22 categories, including primary energy demand, water scarcity, climate change potential, and economic costs, as well as integrating social acceptance considerations into sustainability evaluations. All these lessons strengthen CERTH-CPERI's ability to contribute to future projects and commercial activities in sustainable building energy solutions, offering expertise that spans from early-stage system design to real-world deployment and replication analysis
	Replication Plan: - ER#16 (O): MiniStor: MiniStor footprint impact tool: CERTH-CPERI intends to reuse and further exploit the knowledge developed through the MiniStor footprint impact tool by integrating them into future national and European projects focused on energy storage. Specifically, CERTH plan to apply the environmental and economic assessment tool to new demonstration sites, both in research and commercial projects, adapting it to different technological contexts and geographical conditions. The ability to evaluate 22 environmental impact categories, along with life cycle costing and social acceptance aspects, provides a robust basis for informing decision-making processes for project developers and public authorities. Additionally, potential collaborations with industrial partners, municipalities, and research organizations are foreseen to tailor the tool for specific market needs, such as adapting it for residential, commercial, and district-scale applications. We also plan to refine the tool further based on ongoing advancements in life cycle databases, durability modelling, and updated legislative frameworks. By doing so, CERTH-CPERI aims to contribute to the wider dissemination and replication of sustainable TCM storage solutions, building on the technical achievements and lessons Learnt from the MiniStor project.

CERTH-ITI	**Lessons Learnt and knowledge improvement:** CERTH-ITI is the Information Technology Institute of the CERTH research Centre involved in the MiniStor Project. Their participation covered aspects of data collection and management. Main activities are listed below: - Handling Missing Data: Data gaps occurred across various Demo Sites due to multiple causes. These were addressed using historical data and linear interpolation to estimate and fill in the missing values. - Firmware Update Adaptation: When firmware updates were applied to tools within a project's ecosystem, it often necessitated updates to other interconnected components. To maintain system integrity, close coordination and seamless communication among all responsible partners were essential. - Data Resolution Variability: Sensor and meter data from Demo Sites came in different resolutions. As a result, each Demo Site required a customized data collection configuration. To standardize data processing on the platform, the highest resolution among the sites was adopted as the common format. - Server Power Outages: To mitigate the impact of server downtime, each Demo Site implemented local data storage, allowing the platform to retrieve the data once it was back online. The use of an uninterruptible power supply (UPS) on the server side was also made mandatory to reduce the risk of data loss.
	Replication Plan: CERTH-ITE developed the user interface of the MiniStor system (KER#5) that permit the interaction with the end user. This result is also connected with the MiniStor HWMS. The contributions in terms of results can be listed here: - ER#3 (P): Home Energy Management System (HEMS); - ER#4 (O): Visual Interface; - ER#5 (O): Enhanced Energy Modellers (DR forecasting and optimization tool); - ER#6 (O): Cloud base monitoring Tool and data mine; - ER#18 (O): AR/VR interaction with end-users. CERTH-ITI will utilize the Project outcomes in current and future projects, since the components and modules are central for Thermal Energy Storage and Management applications in general. The technologies will continue to be applied on CERTH's Smart home for further validation and demonstration. Research and development results will be published in peer-reviewed journals or conference proceedings. Key results will be presented to CERTH-ITI commercial partner such as retailers, or aggregators, factory managers and other industrial partners, to gauge the market interest for such services and technologies. Finally, there is potential in exploiting the CERTH-ITI developed modules via their integration in thermal energy-related IoT platforms developed and commercialized by existing or newly established CERTH-ITI spin-offs.
CNRS	**Lessons Learnt and knowledge improvement:** The National Centre for Scientific Research is the larger research organisation in France. It is an active multidisciplinary institution that covers all fields of scientific research driving various programs and actions designed to address society and industry expectations. The participation in MiniStor involves aims to contribute to, environmental sciences and engineering with the purpose to reduce the environmental impact of the building sector. The lessons Learnt from this experience can be listed as: - Better understanding of the thermodynamic behaviour of a high energy density thermochemical storage system.

	- A better understanding of thermodynamic couplings in such hybrid systems, particularly those that enable the control of thermochemical storage reactors by compressors. - Development of numerical tools for the design, development and construction such thermochemical storage systems assisted by mechanical vapour compression.
	Replication Plan: The role of CNRS was fundamental for the design and engineering of the TCM units installed in the pilot sites and the knowledge about this innovation is owned by CNRS in collaboration with Psyctotherm for the ammonia exchanger knowhow. - ER#13 (O): Thermochemical Unit: As a research centre, CNRS can support the future stakeholders in the design and development of such high energy density thermal energy storage solutions. This result will be exploited primary for scientific dissemination and in case of commercialisation with the contribution in the design and engineering of the product.
HSLU	Lessons learnt and knowledge improvement: The Competence Center for Thermal Energy Storage (CCTES) at the Lucerne University of Applied Sciences and Arts (HSLU) was involved in the selection and analysis of suitable phase change materials, the development of the monitoring system for the demonstration units, and the analysis of the measurement data as part of the MiniStor project. The project has led to several important knowledge gains, including: - A deeper insight into the analysis of low temperature phase change materials, as well as achieving a balance between economic feasibility and energy performance optimisation. This knowledge will contribute to significant progress in future research initiatives related to thermal energy storage. - The unification of diverse monitoring systems and the seamless integration of existing infrastructure into a newly developed environment. Participating in a large-scale international research project with a diverse range of research and implementation partners has proven highly enriching. It has helped to optimise the planning and organisation of internal processes and is expected to lead to increased efficiency in future projects.
	Replication Plan: HSLU participated in the development of three ERs, the ER#3 and ER#6 as partner and ER#19 as owner in collaboration with rest of the consortium. - ER#3 (P): Home Energy Management System (HEMS) - ER#6 (P): Cloud base monitoring Tool and data mine - ER#19 (O): Methodology for MiniStor O&M The results of the project will be leveraged by HSLU in numerous future research projects within the field of thermal energy storage, thereby contributing to the decarbonisation of society. In particular, the preparation and accessibility of research data are key to demonstrating the relevance and impact of our research in this field. Furthermore, the outcomes of the MiniStor project will support HSLU in engaging new partners for future research and development efforts in thermal energy storage.
CARTIF	Lessons Learnt and knowledge improvement: CARTIF is a horizontal, private and non-profit technology centre located in Boecillo Technology Park, in Valladolid (Spain) expert in innovative solutions for industrial and residential end users with the scope to improve social and economic development. The contribution in the MiniStor project was focussed to the development of the MiniStor control strategies and the Home Energy Management systems. For CARTIF, this is the first integration of a TCM storage system in a control system. New knowledge about the real operation modes of the TCM and operation conditions were

	acquired during the project, such as the handling of control strategies and transitions between modes for systems with slow responses (high thermal inertia). Challenges related to connectivity and system robustness were identified, which helped us improve fault tolerance. The use of multiple protocols enhanced our knowledge of interoperability. Prediction models based on neural networks were developed to estimate short-term energy generation. The combined use of real data and forecasts improved our understanding of the impact of data quality and availability. An adequate level of accuracy was achieved, with room for improvement as the dataset grows. A high-level control was designed using models of the TCM, PCM, and heat pump, managing their operation based on generation and demand profiles. The control problem was solved through differential equation solvers. Difficulties in replicating certain components, especially the TCM, provided valuable lessons in interoperability and validation.
	Replication Plan: CARTIF as a no profit entities can participate in the market with some restrictions, but they are strongly interested to replicate and reuse the results developed in MiniStor. CARTIF has the ownership of the three ERs listed below: - ER#3 (O): Home Energy Management System (HEMS); - ER#7 (O): HEMS - High level control; - ER#8 (O): Distributed Energy Resource (DER) prediction model. CARTIF plans to build upon the outcomes of MiniStor to strengthen its expertise in smart energy management at residential level. The developed components, including the HEMS system, high-level control algorithms, and the Distributed Energy Resource (DER) prediction model, will be integrated and adapted in future R&D projects focused on local energy communities, smart buildings, or IoT-based energy platforms. Their deployment will continue through validation in real-life settings such as pilots or living labs, with potential upscaling to wider contexts. Collaboration with public and private stakeholders will be explored for the potential transfer and uptake of these results, especially in the field of energy efficiency, forecasting, and automation. Furthermore, the generated knowledge will be disseminated through scientific publications and technical forums.
USC	Lessons Learnt and knowledge improvement: The University of Santiago de Compostela is a public higher education and research, which is made up by the campuses of Santiago de Compostela and Lugo. It provides a public service to the community through study, teaching, research and knowledge transfer at the service of Galician society. USC participated in MiniStor as a demonstrator installing in its student's campus the MiniStor prototype and the PVT plant. The lesson Learnt by this experience are essentially: - Completed full MiniStor installation in a real student residence. - Integrated MiniStor subsystems into one Grafana stack. - Deployed sensors for temperature, energy, and a meteorological station. - Built real-time dashboards and alerting apps (Grafana + mobile app). - Logged ~95 % uptime since installation. - Learnt best practices and regulations for installations in university residences. - Established coordination protocol with university staff and IT teams. - Benefits for future activity: Faster, lower-risk installations of similar energy systems in university buildings, reusable data model and dashboard templates for other smart building projects, improved UI/UX design for energy monitoring apps and improved stakeholder management and shorter installation time on new sites. - Maintenance support needs to improve to speed up incidents that occur. - Certain critical elements of the MiniStor system should be tested to unsure their reliability and that of the system.

	Replication Plan: The intention on USC is to continue the testing of the MiniStor prototype after the project end, collecting more data of entire seasons (heating and cooling). A longer testing period with diverse climatic conditions and a more in-depth analysis of the results is required to better calculate the system efficiency and before the MiniStor system can be replicated in USC buildings. USC is open to collaboration with MiniStor partners and regional stakeholders to deploy results in additional halls or building demonstrators, promoting scientific dissemination.
ENDEF	**Lessons Learnt and knowledge improvement:** EndeF is a technology-based company, specialized in the development and application of solar energy solutions for residential, commercial and industrial sectors located in Zaragoza (Spain). EndeF developed innovative photovoltaic-thermal (PVT) panels used in the MiniStor demo sites for the feeding of the thermal energy. Two models of PVT panels have been considered in the project dependently for the pilot's environmental conditions: Ecomesh and Ecovolt, that permits to optimise the energy production (thermal and electricity) to different climatic zones and locations. The improvement of knowledge coming from MiniStor can be considered in the field of: - The design of the integration between PVTs and a novel TCM storage system, together with the ESS system to optimize the energy use in both, electrical and thermal ranges. - The combination of unglazed PVTs and Heat Pumps as an energy system to be integrated with the TCM-PCM storage medium, and the design of strategies oriented to the commissioning as well as control strategies for the whole system. - According to the testing developed, and due to the temperatures required by the MiniStor system, glazed PVT collectors were more suitable due to them favour thermal energy versus electrical energy, nevertheless, the combination of unglazed PVT with Heat Pump provides a suitable option for the whole system. - Interoperability of the different energy systems, both at physical level and at control level, to manage their operation. - Development of installation strategies for the different demo sites, adapting the equipment to the various requirements.
	Replication Plan: EndeF is already active into the market of solar technologies. Their business strategy is aligned to transform the current energy model into a model focused on people: environmentally, socially and economically sustainable. To achieve this, EndeF distributes its efforts in four strategic lines: Engineering, Manufacturing, Installation and Monitoring that together with the R&D area, give them the possibility of working under an integral method that, through synergies between the different departments, allowing to offer solar solutions in all those phases of the process. - ER#9 (O): Novel PVT System. - ER#10 (O): Water flat plate PVT collectors (Conventional PVT). As a system integrator company, the ER#9 and ER#10 will be pushed into the market starting from the Spanish market - ER#11 (O): Strategies for connecting Conventional PVT, with the TCM storage: - ER#14 (O): Simulation for BESS unit according to PVT electrical production and the electrical load profiles: The ER#11 and ER#12 will support the MiniStor advancements to enhance their technology, by marketing the PVTs and their integration possibilities with the MiniStor system, including the PVT-TCM-ESS and the PVT-HP-TCM-ESS integration. Particularly, the combination of PVT with heat pumps and energy storage technologies is a relevant issue to be implemented.

Enetech	**Lessons Learnt and knowledge improvement:** Enetech is Polish company founded as a spin-off from AGH University of science and technology, working in field of Energy efficiency and Energy storage. Enetech is already present into the energy market with a mobile heat storage based on PCM, that allows to transport Heat via road infrastructure instead of pipelines. They are also active as energy consulting with skills on highest quality energy audits. The scope of the company is to acquire competencies about thermal Energy storage in phase change materials and gain knowledge about benefits of using MiniStor in buildings in Poland. The lessons learnt in the project by Enetech are distributed from the technical activity and the market analysis as a partner contributing in them. By participating in the project, Enetech was able to learn how thermal energy storage technologies in phase change materials cooperate with other energy storage technologies and heat sources. In addition, Enetech gained knowledge on the most promising markets for thermal storage technologies, as well as how MiniStor-related technologies can be implemented in existing buildings to improve their energy efficiency.
	Replication Plan: Enetech will use the experience gained during the project in two ways. The first is related to the further development of the heat storage technology developed by Enetech in phase change materials and its commercialization. Thanks to its participation in the project, Enetech will direct its commercialization activities towards combining the heat storage technology in PCM with other energy storage technologies, as well as joint heat storage with production sources. Additionally, in the case of entering international markets with the product, this will be done first in countries with the greatest potential for implementing the developed technology, which were indirectly identified as part of the project. The second way of using the project results is related to Enetech's activity in the field of energy consulting. Participation in the project allowed the company to verify the effectiveness of individual technologies used in MiniStor in improving the energy efficiency of buildings, thanks to which, when carrying out future energy audits and other tasks related to improving energy efficiency, Enetech will be able to indicate the appropriate, most effective technologies, both in the context of energy sources and methods of its storage.
SGS Tecnos	**Lessons Learnt and knowledge improvement:** SGS Tecnos is a multinational company leader in certification, inspections, verification and testing, with long experience in certifications for the energy sector. As energy efficiency and certification is one of the core businesses of SGS work, the enterprise seeks to improve the energy performance of its clients and partners, by assuring the safety and effectiveness of energy facilities. The main knowledge learnt in the project are: – Gain a deeper understanding of energy storage systems and their applications in residential environments. – Explore the options for ammonia-based energy installations in residential environments. – A deeper understanding of the EN378 standard has been achieved. Lack of local regulatory development in European countries regarding the use of ammonia in residential environments.
	Replication Plan: As consultant company the knowledge learnt in the MiniStor project will be reused in other research activities in the field of thermal energy storages and ammonia-based technologies. A particular attention will be placed on the improvement of standards and regulation that can facilitate the market penetration of the ammonia-based solutions.

EMI	**Lessons Learnt and knowledge improvement:** EMI is a Hungarian non-profit company for quality control and innovation in building sector. They are active in testing and demonstration of innovative solutions for construction integrating building materials, passive technologies and sustainable systems. The main activities where they have expertise are issuing technical approvals and assessments, testing, inspection, laboratory experiences, research and development, certification and trainings for professionals from blue collar workers to engineers and inspectors. In MiniStor they participated as a testing laboratory, learning the knowledge for the installation and connection of the system with the user. In this context, EMI participated in the efficiency assessment of the System measuring the energy consumed and provided by the System and producing the deliverable D6.3. The most important experience in the testing process is related to the measurement of the energy conversion process and the input energies in steady-stationary manner, to exclude all weather-dependent conditions can be excluded. In this process EMI used a mechanical system to dissipate the converted thermal energy generated by the MiniStor as a building simulator, with a testing procedure like an engine without the car. To make the measurements properly, the instrumentation has been chosen so that the input electrical and solar energies, as well as the output cooling, heating and DHW energies, can be determined directly or by calculation.
	Replication Plan: The experience Learnt in the testing procedure will be fundamental to improve the MiniStor efficiency in the TRL upscaling process and in the optimisation of the installation costs. - **ER#12 (O): Hybrid Energy Storage testing procedures:** All the knowledge Learnt in the testing procedure will be reused to optimise the system to increase the TRL and the efficiency. The interest of EMI is to continue to work on the prototype installed in their laboratories and building, contribution to ither research activities as well as to develop scientific dissemination in papers and scientific journals.
Woodsping	**Lessons Learnt and knowledge improvement:** Woodspring is a research SME interested in innovative products and technologies in the energy efficiency of buildings and environmental sciences, with a consolidated experience in space heating with natural resources. The company have participated in more building processes of test houses and development of the innovative elements such as seasonal storage system, intelligent windows system, and thermal reflecting insulation system. From the participation in MiniStor, Woodspring have understood the operational principle of the MiniStor based on TCM and PCM and experienced the energy gaining potential of those innovations. We experienced how to connect to a MiniStor heating and DHW system and how to regulate the heating and cooling demand of the building. In addition, we have gained experience of installation of solar field and the connection to the MiniStor and feel the dimensioning of solar input concerning the expected energy demand of the building.
	Replication Plan: Woodspring is interested to exploit the result of MiniStor, as integrated solution (TES+PCM+STP) through consulting and market activity directly in the Hungarian building retail market. In case the MiniStor solutions will reach the market, Woodspring is available to operate as a local distributor, supporting the selling into the Hungarian building renovation market and proposing this solution in the new low-energy demand buildings. The lesson Learnt in the project will permit to Woodspring to provide design and dimensioning of the MiniStor system and the related solar plant.

Cork City	**Lessons Learnt and knowledge improvement:** The Cork City Council is the local authority for the city of Cork, the second largest city of Ireland, located in the southwest of the country. Cork City Council manages the cities social housing stock of over 10,000 homes and participated in the MiniStor project as a pilot with the purpose to test innovative solution for the promotion of sustainable heating and cooling. With the participation in the project the Cork City Council Learnt the potentiality of the MiniStor solution and the procedures for the authorization and installation in a residential house.
	Replication Plan: The internation of the Cork City Council for the exploitation of the knowledge Learnt in the project is to continue to monitor the performances of the MiniStor prototype in the demo case and share useful information for the TRL upscaling of the entire system. At the same time the lessons Learnt will be used to disseminate scientific knowledge in the Irish country and promote sustainable measures in the residential sectors.
DUTH	**Lessons Learnt and knowledge improvement:** Democritus University of Thrace is one of the most important universities of the Greece located in Northern East Greece. The benefits from the participation in the MiniStor project increases the knowledge about the thermal energy storage systems, with particular focus in the development and exploitation. Relevant point of interest can be listed here: - Thermal and cooling energy are important actors of the energy map. - Existing fossil-fuel based technologies are neither environmentally viable, nor economically feasible when compared to renewable energy-based systems. - District heating/cooling networks have proven their importance to the energy market. - Storage technologies (such as PCMs, TCMs or thermal energy storage—TES) accompanying district heating and cooling networks can aid the increase of the feasibility and economic indicators of these systems. - Community level interconnection of energy production systems and central district networks is a proven and viable solution towards CO_2 reduction and economic blooming. - In the energy transition the participation of the end user is of decisive importance. - On the question of what we would do differently to reach the exploitation aims we would suggest greater involvement of the government (at central and regional level) to inform, motivate, define the legal framework of partners such as municipalities, chambers of industry, etc. to be more actively involved in such energy democratization processes.
	Replication Plan: The technologies installed within the framework of the MiniStor project are already in use, producing and storing energy. The DUTH pilot site is already participating in other EU funded project, sharing results obtained during MiniStor and carrying out research on technologies with a different scope i.e., increasing energy efficiency of buildings through deep retrofitting and towards NZEB. DUTH is active in engaging in EU proposals, especially in Horizon Europe, for capitalizing on results of previous projects, while expanding its know-how and expertise fostering energy communities. The target market includes other student accommodation premises in DUTH and in other Greek universities but also social housing in southeast Europe due to the similar climatic conditions, offering opportunities for the efficient and optimum integration of RE systems in the built environment. Direct target users were mainly students, but other types of stakeholders will be reached such as the local authorities, housing cooperatives, policy makers, businesses, as well as engineers on the building and energy sector. In addition, research and academia institutions will also be reached through the scientific exploitation of the project results and pilot site operation.

FEUGA	**Lessons Learnt and knowledge improvement:** FEUGA has had a supportive role within MiniStor, overseeing WP8 Communication and Dissemination tasks, and being co-responsible for the networking, standardisation and policy-making efforts. MiniStor has enabled FEUGA to deepen expertise in open innovation, policy and standardisation with the production of 4 technical documents, further reinforcing its background on the thermal energy storage and building sectors and their value chains. On top of that, the project extended FEUGA's networks through more than ten collaborations with normalisation and certification bodies and initiatives, energy and construction clusters, and European Technology and Innovation Platforms. The Final and Midterm Conferences organised by FEUGA provided B2B opportunities while also attracting end-users and stakeholders, a broader audience and a priority for the European Union.
	Replication Plan: Aligning with FEUGA's foundational mission, the extended networks obtained will allow the organisation to explore new avenues for collaboration in knowledge transfer within and outside the energy and construction sectors, resulting in additional opportunities and funding for Galician academia, industry and SMEs. The policy and standardisation documents to which FEUGA contributed will be exploited for the knowledge and technology transfer in the TES sector. On broader terms, the frameworks developed in MiniStor, and their implementation plans will be exploited for consultancy services about the methodology for other industrial markets on specific communication and dissemination strategy design in the target markets.
R2M Solution	**Lessons Learnt and knowledge improvement:** R2M Solution works as an innovation accelerator for sustainable building solutions and technologies into the buildings retail market in Italy, Spain and France, connecting directly innovation solutions from the financed research into the market. R2M Solution is also able to support the financial aspect for the integration of innovation technology by EPC contracts and ESCo approaches. As innovation and exploitation manager for the MiniStor project, R2M leaned the main characteristics of the innovative thermal storage, the potentiality of its innovations into the market and the barriers for the market uptake.
	Replication Plan: All the knowledge Learnt in the R2M participation can be exploited in consultant services for the MiniStor TRL upscaling or in other projects. - ER#15 (P): MiniStor time and cost-effective construction methods: R2M participated in the cost assessment of the MiniStor prototype and developed a cost assessment for the acceptance of this innovation into the market, considering the benefits and the costs at customer segment level. This experience can be replicated to optimise the MiniStor TRL upscaling and the production in large scale. At the same time this experience can be replicated with other innovations outside the MiniStor context. - ER#17 (O): MiniStor: Circular economy MiniStor Business Model: The business model proposed for the MiniStor project is based on a detailed market research of circularity economy. It takes in consideration the best consolidates experiences of circularity models of technological products (PV and Lithium batteries). This result could facilitate the sustainability of the MiniStor TRL upscaling and the costs reduction once the business model will be in place. This approach is also fundamental to guarantee the economic sustainability of goods and services into the EU context avoiding external dependencies that can create bottlenecks or blocking points at the product value chain.

Sofrigam	**Lessons Learnt and knowledge improvement:** Sofrigam is a leading enterprise with extensive experience in designing, manufacturing and marketing cold chain solutions. They meet the most demanding needs of the pharmaceutical and biotechnology industries. Their passive and active temperature-controlled solutions and full integrated services use the most energy-efficient technologies available, offering significant advantages. Sofrigam's contribution to the MiniStor project focuses on the development of the TCM reactor.
	Replication Plan: Acting as the technology provider for the TCM units presents an opportunity for Sofrigam to explore other market sectors and enhance its expertise in ammonia systems. The knowledge gained will be applied to future consultancy activities. In particular, the experience gained from MiniStro will be fundamental for their business and could open new avenues for the company. At the same time the replication in the MiniStor start-up, for the commercialisation of the KER#1 and KER#4 could be a solid business opportunity.
Psyctotherm	**Lessons Learnt and knowledge improvement:** Psyctotherm is a Greeks SME specialised in the design, development, and commercialisation of heat exchangers and heat pumps systems for the building, industrial and marine refrigeration. With a strong experience in the engines for waste heat recovery based on Organic Rankine Cycles, Psyctotherm developed the MiniStor TCM reactor, heart of the MiniStor system. Throughout the MiniStor project, Psyctotherm gained significant experience and advanced knowledge in the design, integration, and control strategies of thermochemical energy systems operating with ammonia. One of the most significant developments was the understanding of how to effectively integrate TCM systems with other renewable and thermal technologies, including solar thermal collectors, heat pumps, and phase change materials. This integration required a study of each component compatibility, system architecture, and control strategy design to enable stable and efficient operation across varying conditions. Emphasis was given on identifying which components are essential for optimal system configuration, ensuring seamless operating among subsystems. These efforts have contributed to a broader understanding of how such systems can be efficiently arranged and managed, both from an operational and control perspective. Another key factor of knowledge improvement focused on the operation and control of the TCM system, with valuable lessons Learnt in the field of ammonia liquid measurements. The use of appropriate sensors to achieve reliable measurements over the time was found to be critical for system safety and performance. For example, inaccuracies in ammonia level readings were shown to lead to reduced mass flow at the compressor suction, potentially resulting in inadequate lubrication and reduced compressor reliability. This insight emphasized the importance of precise monitoring and triggered the development of enhanced safety measures. To deal with this, using the integrated pressure sensors of the system, the control algorithm was modified to regulate compressor operation based on predefined minimum and maximum pressure thresholds. Furthermore, by continuously evaluating the operating pressure ratio, the compressor speed was dynamically adjusted using advanced PID control algorithms, to ensure operation within the compressor's performance map, thus improving energy efficiency, safety, and extending the equipment's lifespan. Another important area of knowledge improvement involved the management of thermal fluctuations, especially during periods of high solar input. To address this challenge, the control algorithm of the thermochemical reactor was modified to ensure safe operation, with the system configured to bypass the hot water when the solar supply temperature exceeded predefined safety thresholds and thereby protecting the reactor from potential overheating. In parallel, compressor performance was further optimized through the implementation of an ammonia liquid injection strategy. This function is triggered when either the refrigerant superheat surpasses a specific setpoint or the compressor discharge temperature exceeds its operational limit. By injecting liquid ammonia at the compressor suction, the system

	enhances thermal regulation, ensuring reliable and efficient operation under different thermal loads.
	Replication Plan: The contribution off Psyctotherm in the MiniStor result was fundamental and concentrated in the ammonia process in the TCM unit. - ER#13 (P): Thermochemical Unit The intention of Psyctotherm for the replicability of the result is to participate in future TRL upscaling and system performance improvement. At the same time, they want to use the lessons Learnt about the use of ammonia in other consultant services and business activity.

5. Conclusion

The MiniStor project has demonstrated a high level of innovation in the topic addressed during its lifetime, which is well reflected in the 19 exploitable results identified by the exploitation strategy and in more specific way, in the five key exploitable result selected and analysed.

All the partners of the consortium actively participated in the exploitation roadmap, providing useful contributions for the results identification and contextualization of the results, as well as for the definition of the replication strategy.

Most of the results have their own replication and well-defined strategy, which is reflected in the business vision of their company (owners).

In the case of a few results, we can consider a joint replication model, characterised by the contribution of more than one company in the development inside MiniStor.

All the results detailed in the Table 2 have reached the TRL 7, that represents a solution demonstrated in a pilot site. However, this is not sufficient to define a strong replication strategy as relevant improvements are still needed at the technological level to reach the next TRL. This aspect also emerged from the BOSAT assessment and the radar mapping (chapter 0).

The main result of the project, the thermal energy storage based on ammonia based TCM technology (KER#4), that represent the heart of the MiniStor solution (KER#1) demonstrated the high thermal capacity, as foreseen in the proposal phase, but in terms of system efficiency there are several improvements and optimisation to be performed based on the demonstration experience. For this regard, the intention of the pilots to continue the data collection and the monitoring of the prototypes represent a great opportunity to increase the TRL. The KER assessment and the BOSAT analysis make in evidence the points where it is needed to focus the future analysis to guarantee the TRL upscaling.

As a final consideration from the exploitation strategy, it is fundamental to mention that current standards, norms and safety regulation for the use of ammonia play a relevant role in the integration of TCM technologies in the different sectors where it can be used. This aspect can prove as a potential bottleneck for market penetration of this novel technology in the residential sector. Even if the entire MiniStor solution (KER#1) represents a unicorn innovation for the decarbonisation of the residential sector, the limits imposed by the regulation on the amount of ammonia (mass) that can be used at building level without periodic inspections by a relevant authority (with consequential added costs), severely reduce the market penetration for this technology by not being able to exploit the full potential of thermochemical energy storage. In fact, this aspect doesn't permit a modularity application and blocks the scale-up to larger residential building installations such as apartment buildings. The second relevant impact from this aspect is reflected in the cost of the technology in order to meet the regulations of EN 378, which is more aimed to large-scale industrial application and does not consider recent advances in manufacturing such as specialized welding of the TCM reactor.

On the other hand, the MiniStor solution has the potential to be applied in other customer segments that were not in the scope of the project. These include sport and wellness centres, hospitality such as hotels, and tertiary buildings with industrial application. The scale of energy storage in those sectors can justify the associated costs of compliance with ammonia safety regulations, presenting as a promising opportunity to acquire a significant market share.

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Annex I –Risks and Impact table

Table 11. Risks and Impact assessment input table

No	ER name	Type	ER manger	Economic Impact						Envinromental Impact			Societal Impact				Risks Analysis								
				Ecl.1	Ecl.2	Ecl.3	Ecl.4	Ecl.5	Ecl.6	Envi.1	Envi.2	Envi.3	Socl.1	Socl.2	Socl.3	Total IMPACT	Risk.1	Risk.2	Risk.3	Risk.4	Risk.5	Risk.6	Risk.7	Risk.8	Total RISK
ER1	MiniStor Compact Energy Storage	Product	R2M	4	4	4	3	5	4	4	4	4	3	3	3	45	2	2	2	3	5	2	2	2	20
ER2	Software model to implement the system in state-of-the-art whole-building energy modelling programs	Model	IERC	5	3	5	3	3	3	3	3	2	5	3	5	43	1	3	3	1	1	1	1	1	12
ER3	Home Energy Management System (HEMS)	Product	CARTIF	3	3	5	3	5	5	3	2	2	3	3	3	40	2	2	4	2	2	2	1	1	16
ER4	Visual Interface IoT-platform for user interaction	Software	CERTH-ITI	4	4	3	4	4	5	3	3	4	2	2	1	39	3	3	2	3	4	2	1	1	19
ER5	Enhanced Energy Modellers (DR forecasting)	Software	CERTH-ITI	1	1	1	1	1	1	3	3	5	3	3	3	26	3	3	4	3	4	3	2	2	24
ER6	Cloud base monitoring Tool and data mine	Software	CERTH-ITI	2	4	3	4	2	1	2	2	2	1	1	1	25	1	5	5	3	2	1	1	1	19
ER7	HEMS - High level control	Knowledge	CARTIF	2	2	5	3	3	2	2	2	1	3	3	1	29	3	2	3	3	3	3	2	1	20
ER8	Distributed Energy Resource (DER) prediction model	Model	CARTIF	4	4	1	5	3	5	2	2	1	1	4	1	33	4	3	3	4	4	3	1	1	23
ER9	Novel PVT System	Product	ENDEF	4	3	4	4	2	3	4	4	3	2	2	4	39	1	3	3	2	3	3	4	1	20
ER10	Water flat plate PVT collectors (Convencional PVT)	Product	ENDEF	4	2	3	4	2	2	4	4	3	2	2	4	36	1	4	3	2	3	3	4	1	21
ER11	Strategies for connecting Conventional PVT, with the TCM storage	Knowledge	ENDEF	3	2	3	4	2	2	4	4	3	2	2	4	35	2	1	2	1	2	2	3	3	16
ER12	Hybrid Energy Storage testing procedures	Knowledge	EMI	3	3	1	4	4	2	4	4	4	3	4	2	38	4	1	1	1	1	1	5	1	15
ER13	Thermochemical Unit (TCM)	Product	CNRS	5	5	3	5	5	3	5	5	4	5	5	3	53	1	3	3	3	5	3	1	1	20
ER14	Stratgies fro integration of BESS Unit with TES	Knowledge	ENDEF	4	4	4	4	4	4	3	3	3	2	2	4	41	4	3	3	2	2	4	4	3	25
ER15	MiniStor time and cost-effective construction methods	Methodology	IERC	4	4	4	4	3	3	3	3	2	5	4	2	41	1	3	1	1	3	1	1	1	12
ER16	MiniStor footprint impact tool	Software	CERTH-CPERI	1	1	1	1	1	1	3	2	2	1	2	1	17	2	1	3	4	1	2	3	5	21
ER17	Circular economy Ministor Business Model	Knowledge	R2M	4	5	4	5	3	5	4	4	1	2	2	4	43	4	3	3	4	2	4	4	2	26
ER18	AR/VR interaction with end-users	Knowledge	CERTH-ITI	3	2	2	2	2	2	2	2	2	1	1	1	22	2	2	2	2	2	2	2	2	16
ER19	Methodology for Ministor O&M	Methodology	HSLU	2	2	1	2	1	5	3	3	5	1	2	1	28	1	3	2	2	3	2	4	3	20

Annex II –Exploitable Resoult Table consolidated vertion 1

The table below reposts the Exploitable Result table presented in the deliverable 7.4 to provide a clear ER assessment process

Table 12 – Exploitable Result table version 1

#	Exploitable Result	Type	WP	ER Manager
1	MiniStor compact energy Storage	Product	WP3, WP4, WP5, WP6	R2M
2	Software model to implement the system in state-of-the-art whole-building energy modelling programs	Knowledge	WP3	IERC
3	Home Energy Management System (HEMS)	Product	WP5	ITI
4	IoT-platform for user interaction	Software	WP5	CERTH
5	Enhanced Energy Modellers (DR forecasting and optimization tool)	Software	WP3, WP5	CERTH
6	Cloud base monitoring Tool and data mine	Software	WP5, WP6	CERTH
7	HEMS - High level control	Knowledge	WP5	CARTIF
8	Distributed Energy Resource (DER) prediction model	Knowledge	WP5	CARTIF
9	Novel PVT System	Product	WP3	EDILIANS
10	Water flat plate PVT collectors (Conventional PVT)	Product	WP3	ENDEF
11	Strategies for connecting Conventional PVT, with the TCM storage	Knowledge	WP3	ENDEF
12	Hybrid Energy Storage testing procedures	Knowledge	WP6	EMI
13	Thermochemical Unit (TCM)	Product	WP4	SOF
14	Latent Heat Storage (LHS) Units with PCM materials	Product	WP4	PSY
15	Water circuits and PCM Heat Exchangers	Product	WP4	PSY
16	Strategies for integration of Building Electrical Storage System (BESS) Unit with thermal energy storage (TES) of MiniStor project	Knowledge	WP3, WP5	ENDEF
17	MiniStor time and cost-effective construction methods	Knowledge	WP3, WP5	IERC
18	MiniStor footprint impact tool	Software	WP7	CERTH
19	MiniStor Startup (SME)	Knowledge	WP7	R2M
20	Circular economy MiniStor Business Model	Knowledge	WP6, WP7	R2M
21	AR/VR interaction with end-users	Knowledge	WP3	CERTH
22	Methodology for MiniStor O&M	Knowledge	WP2, WP7	HSLU

Annex III –BOSAT questionnaire

Table 13. BOSAT questionnaire

Technology
T1. Is the BO a unique technology? • The technology can change the way in which the industry operates / works • The technology shows some improvement in relation to existing technology • The technology has a marginal effect in relation to existing technology • The technology shows an improvement in relation to existing technology
T2. Is the BO technically superior to substitute technology? • There is substitute technology which is not yet competitive • There is a reasonably wide range of substitute technologies • There are no known substitute technologies • There is substitute technology, but it is limited in use and range • The technology is representative of a field where there are new, substitute and dominating technologies
T3. To what extent has the technology been tested and validated? • I am still in the ideation phase • Basic principles and technology concept have been formulated (TRL 1-2) • There have been repeated experimental tests and validation tests in a lab environment (TRL3-4) • There have been validation tests in a significant environment (TRL 5-6) • There has been prototype demonstration in operational environment (TRL 7)
T4. Are infringing copycat products easy to produce? • The technology is easy to copy and reproduce by a skilled team in the art • The technology is easy to copy and reproduce by any similar R&D center • The technology is very easy to copy and reproduce by any company • The technology is difficult to copy and reproduce by a skilled team in the art
T5. Do you know how to translate your BO into a usable/marketable solution? • Not yet, I am focusing on developing the technology • Yes, I am doing this with the support of TTO / experts / coaches • Yes, I have developed a strategy for addressing the solution and received feedback from early adopters • Yes, I have developed a strategy for addressing the solution • Yes, I have an idea of a product for a usable solution
T6. Have you performed a risk analysis related to the technology of your BO? (significant dependency on other technologies, life cycle of technology too short, lower performance than expected etc.) • Yes, I identified and ranked risks • Yes, I incorporated measures into our business strategy and planning to avoid the identified risks • Not yet • Yes, I identified risks and weaknesses • Yes, I imagined precautionary measures to lower the identified risks
Team
Tm1. Do you have a team? • Yes, we are a group and we are about to formalize our team • No, I am by myself • Yes, we are a formalized team
Tm2. Do you have a team building and team development plan? • The team is complete, roles are defined and team development procedures in place • I have negotiated with potential team members, still waiting for their responses • The team is complete, the roles and competences development plan established • No, not yet • The team is still incomplete; team development plan is established

Tm3. What percentage of time do the team members foresee to dedicate to the BO? • All team members work less than 50% on the BO and we do not foresee an increase in our time spend • All team members are full-time dedicated to the BO • All team members work less than 50% on the BO, but we envisage increasing our time spend • There is at least one full time team member dedicated to the BO • There is at least one team member spending more than 50% of his/her time on the BO
Tm4. Is there a clear structure in the team with separation of roles (decisions making procedures in place, etc.)? • Yes, we have a clear separation of roles and a plan to cover missing ones • No, it is a single effort • Yes, we have a clear structure in place and all key roles are filled in • No, it is a small team • Yes, we have a basic separation of roles
Tm5. Have the leadership skills of the person in charge of the team been proved (understands the mission, works well with others, shares team values, gets results, respects and inspires others, is respected by others, delegates appropriately, listens and communicates effectively)? • Yes, by his/her peers • Yes, he/she is an experienced project manager • We don't have a team leader • No • Yes, by his/her team members
Tm6. How is information communicated between team members? (reaches the right people, appropriate information, timely, open and honest, respectful, interactive, secure and confidential) • Communication protocols and tools are used but still there are issues with the communication flow • Main mode of communication is scattered. People are not sharing information with each other, or irrelevant people are copied, or too much/too little information is provided • Through non-formal communication • Regular meetings and tools used by everyone on a regular basis • Regular meetings are held and resource banks exist, but not everyone knows what resources there are and how to access them
Tm7. Does the team provide internally all the tech skills needed for the project development? • No, we have external collaborations • Yes, we have a dedicated team internally • Yes, but we also rely on external collaborators
Tm8. Has the team previous experience in commercializing research results? • Yes, at least one of the full-time members exited with success from a spin-off/startup or sold more than one license • No • Yes, at least one of the full-time members was part of a spin-off/startup or sold a technology • Yes, at least one of the team members was part of a spin-off/startup or sold a technology
Tm9. Do you have people dedicated to marketing and sales in your team? • Yes, we have an internal division with more than 5 years of experience • Yes, with more than 5 years of experience combined • Yes, with less than 5 years of experience combined • No • Yes, with less than 1-year experience combined
Tm10. Do you have experience raising funds within the team? • Yes, there is at least one team member who raised between €50k-€200k • No, but we rely on experts inside our institution • Yes, there is at least one team member who raised funds at international level through private donors/investors • Yes, there is at least one team member who raised both public and private funds at national/international level • Yes, there is at least one team member who raised public funds at national level

Tm11. Is the core team willing to self-finance next steps? • No • Yes, we already committed some money • Yes, we are discussing it
Tm12. Is the team committed to commercialising the BO? • Yes, we already started the commercialisation process of the BO • No, the team is not interested in commercialisation • Yes, the majority of us are committed to commercialising the BO together • Yes, we are planning next steps towards commercialisation • Yes, at least one of us is committed to commercialise the BO
Tm13. In order to commercialize you are expected to be geographically flexible. Are your team members willing to relocate, even abroad if needed? • No • Yes
Tm14. Are team members sufficiently aware of all risks to team performance (internal conflicts, politics, confidentiality, conflicting agendas and priorities, etc.)? • A verbal agreement regarding these issues exists • We talked about these risks • No • Official procedures exist • Informal written procedures exist
Tm15. Is the team open to go through a mentorship program? • Yes, the team is willing to be coached and has proposals or ideas for a program • No, the team wants to manage the project and the commercialisation of the BO by themselves • Yes, the team is quite open to enter in a mentorship program • Yes, maybe the team could get some help with some aspects • Yes, the team is really willing to be coached
Market
M1. Is your BO addressing identified and validated customer needs? • Yes, I have identified customer needs and validated them with potential customers • No, I still haven't identified customer needs • Yes, I have identified a number of needs that we could satisfy
M2. Has the market need been validated and how was it done? • Yes, I obtained reports from relevant databases • No • Yes, the need was validated directly by our partners (investors, industry etc.) • Yes, an external consultant validated the need • Yes, I did it by internet search
M3. Have you performed a market analysis and how was it done? • No • Yes, at national level, with the support of a TTO / expert • Yes, at global level, with the support of a TTO / expert • Yes, at European level, with the support of a TTO / expert • Yes, by myself
M4. How regulated is the target market? • The regulations are high but well-defined or there is a low risk of refusal • There are very complex regulations, unfavourable regulations or a high risk of refusal • There is a low level of regulations or there is no risk of refusal • The regulations are high and unclear or there is a risk of refusal • There are new regulations that are favourable for commercializing the technology

M5. Have you searched for other existing solutions(products) that respond to the same customer need that you are addressing (competitors)?

- Yes, at national level, with the support of an expert / industry partner
- No
- Yes, at global level, with the support of an expert / industry partner
- Yes, at European level, with the support of an expert / industry partner
- Yes, by myself through internet search

M6. Are competitive or substitute products active in the market?

- It is probable that competitive or substitute technology is being developed
- The BO will provide an exclusive solution to the market
- I do not know
- There is a good probability of exclusivity in the market
- There is a high degree of development of competitive or substitute technology

M7. When assessing potential customers were you able to identify early adopters?

- No, I haven't identified early adopters, I am contacting them all
- No, I don't know who my customers are
- Yes, I identified potential early adopters at international level and they provided positive feedback
- Yes, I identified potential early adopters a regional/national level and they provided positive feedback
- Yes, I identified potential early adopters and I have contacted them

M8. Have you developed a marketing plan for your business opportunity?

- No, I have not
- Yes, built on our previous experiences in going to market
- Yes, I am preparing it right now with the help of an expert at national level
- Yes, I am preparing it by myself

M9. Has there been any commercial interest in your BO?

- No, potential customers were only identified
- No, potential customers were identified and approached but no feedback was obtained
- Potential customers have provided a positive feedback
- We are in negotiation with some potential customer
- Customers are secured / have signed a contract

M10. What knowledge do you have of the application potential of your technology?

- I have no knowledge of the application potential
- I validated the application potential with team members
- I validated the application potential with external consultant
- I validated the application potential with external consultant and commercial opportunities have been identified
- I have some ideas about the application potential

M11. Do you have a clear view of the process and the time needed to achieve a market launch?

- I have a clear plan regarding the industrialisation process and a clear timetable
- No, I have not discussed it yet
- I have a plan, technology wise
- I have a clear view of the whole process for launching on the market, including sales and marketing activities
- I have a clear view of the industrialisation/delivery plan and of the validation and authorisation process and schedule to launch the product

Unique Value Proposition

U1. Has the UVP been validated?

- No
- I don't have an UVP yet
- Yes, externally by clients
- Yes, externally by expert/s
- Yes, internally, by team members

U2. Can you measure the added value of your BO? • No, I cannot • Yes, I can in a qualitative and quantitative way • Yes, I can in a qualitative way
U3. Can you communicate the benefits of your BO in a short message that is easy to understand? • No, my solution is too complicate to communicate as there are many technical details • Yes, I can without adding technical details and I have messages prepared for each of our target groups • Yes, I can do it with some reference to technical details • Yes, but I need to add technical details to a large extent
U4. Can you position the added value of your BO in the value chain? • Yes, we have a value chain map • No, I have not considered it • Yes, but not all relevant actors are yet identified
Intellectual Property
I1. Is the owner of the IP relating to the BO identified? • No, the IP ownership is unknown • Yes, there are different well identified owners but there is no ownership agreement yet • Yes, a sole owner has been clearly determined • Yes, there are multiple owners and this is specified in an ownership agreement or contract • No, the IP ownership is unclear; some rights may be owned by a third party
I2. Has the confidentiality of the results been maintained? • There has been some partial disclosure without any key elements • There has been some partial disclosure but containing some key elements • No, there has been a disclosure of the results (paper, abstract, poster, oral presentation, etc.) • There has been no disclosure at all • There has been some disclosure under confidentiality agreements
I3. Does the BO include the institution's sole results only? • Yes, and there is no NDA from a third party involved • No, the BO includes confidential results from a third party or involves the use of material from a third party, without any contract • I don't know • No, the BO involves material from a third party but with a MTA contract allowing their use • No, the BO includes confidential results from a third party but with an NDA contract
I4. Are the experiments/observations leading to the BO described in a laboratory notebook? • No, nothing has been written down • All observations are written in a professional (paper or electronic) notebook that is dated and signed by a supervisor • Some observations are written in a personal notebook but have not been dated • Observations can be found in a notebook that is dated and signed by a supervisor • Some observations can be found in a personal notebook that is dated
I5. Has a strategy for protection been defined? • Part of the strategy is defined. One aspect of the BO will be protected with consideration of a first targeted market • No • All the different aspects of the BO have been considered and a suitable protection for each aspect is defined, with consideration of first and future targeted·market and territories • A strategy of protection has been defined for one major aspect of the BO with consideration of a first and future targeted market • Part of the strategy is defined. Several aspects of the BO will be protected with consideration of a first targeted market

I6. Have you considered the life cycle of your BO for your IP rights strategy? • I considered the life cycle of the BO but the technical field is moving so quickly that patents or any other IP rights are irrelevant • This was not considered • I considered the life cycle and there is good adequacy between the BO and IP rights • Experts consider that the life cycle of the BO is in good adequacy with IP rights • I considered the life cycle of the BO but adequacy is difficult to find because the BO is so early and/or the time to develop it so long that patents will expire or • cost too much before products will reach the market
I7. Which IP rights (patent, copyright, trademark, trade secret, registered design, sui generis database right, etc.) have you considered to protect your BO? • All IP rights have been considered and at least one is in place • Only one IP right has been considered by the team • I have no idea; none have been considered yet • Some IP rights have been considered and at least one will be used • Some IP rights have been considered but none can be used
I8. Has a prior art search been performed? • A search report was issued by a Patent Office • I did it by myself • No novelty search was done • I did it with the help of some of the team member/colleagues • A detailed search was performed by an expert
I9. Are products of infringing nature easy to identify? • It is possible to identify infringing copycat products • It is difficult to identify infringing copycat products • There is no way to detect the use of the technology on the market • It is obvious to identify infringing copycat products • It is easy to detect the use of the technology on the market
I10. What is the patent status of your BO? • A national patent application was submitted • Not applicable • At least one national patent was granted and patent applications are pending in other countries • National patents are granted at international level, according to the outcomes of the business and marketing plans • An international patent application was submitted
I11. Have you performed a risk analysis related to IP rights? (e.g. disagreement on ownership rules, patent infringement, easy to copycat, leaks of confidential information etc.) • Not yet • Yes, I incorporated counterfeiting measures into our business strategy and planning • Yes, I identified the risks and weaknesses • Yes, I developed precautionary measures and addressed them in advance • Yes, I identified and ranked risks
I12. Does the use of the technology depend on license agreements with others (because the technology is within the scope of external patent or IP)? • The use of the technology is totally independent of any license agreements • The use of the technology is dependent on extensive license agreements with competitors • The use of the technology is dependent on license agreements, but not with competitors • The use of the technology is dependent on some license agreements with competitors
Financials
F1. Have you ever attempted to raise funds, debt and/or equity to develop your project? • Yes, for a prototype • No • Yes, to prove the concept • Yes, to protect the IP • Yes, only public funds for further research

F2. Have you already contacted any potential investors different from those providing grants? • Yes, at national level • Yes, at national and international level • No
F3. What access to funding do you have available at local/national level for the development phase? • I do not know • Access to a funding of prototype and testing • Access to a funding of the Proof of Concept (POC) • Access to a funding to cover the whole development phase • Access to a funding of IP protection
F4. What access to funding do you have for the scaling up phase? • I do not know • Access to early-stage investors, such as business angels, crowd funding • Access to institutional/governmental funds • Access to formalised investors such as venture capitalists or industry funds • Access to friends & family funding
F5. If you obtain funds, is there a clear action plan on how to use them? • No • Yes, I made the estimations with the support of experts • Yes, I made estimations by myself • No, I am working on it in the preparation of the business plan
F5. If you obtain funds, is there a clear action plan on how to use them? • No • Yes, I made the estimations with the support of experts • Yes, I made estimations by myself • No, I am working on it in the preparation of the business plan
F7. To what extent have the financial needs been evaluated? • Development costs have been evaluated • No evaluation has been done • Development, industrialisation, launch and sales costs (sales, distributions, marketing) have been evaluated • Development, industrialization and costs for launching on the market (validation, accreditations, regulatory costs) have been evaluated • Industrialisation (production, tools, investment) costs have been evaluated
F8. How developed is your BO in terms of revenue generation? • We are collecting the first revenues • We have no estimations • We have identified the business model • We have identified revenue streams and quantified them with KPIs and milestones to be achieved • We are assessing different scenarios
F9. Have you estimated what will be the eventual price of your BO? • Yes, it has been estimated within our market research with an external expert • No, it is too early to estimate the price • Yes, it was estimated internally, within the team
F10. To what extent has the business plan been prepared? • I have no idea of the business plan • I can estimate the Profits & Losses of the BO for 5 years • I have set up forecasts for sales • I have set up the cost structure of the BO • I have already set up a business model
F11. Are you aware of possible support programmes or infrastructure available for BO development?

- I have no idea
- I am already working with the office/hub and programme that supports BO development
- I know one entity/office/hub and one programme that supports BO development (such as Mentorship, Start-up Lab, Grant, Competition, Hackathon, etc.) at
- national level
- I know more than one office/hub and programme that supports BO development at national level
- I know at least one person involved in BO development (IP protection / entrepreneurship / commercialisation)