D7.1 Design evaluation through user validation in pre-demonstration site

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D7.1 Design evaluation through user validation in pre-demonstration site

Summary	
The current deliverable presents a first evaluation of the proposed MiniStor design of the user interaction, configuration, features and interfaces and features based on feedback from representative subjects. The procedure of determining this design is also included and thoroughly explained. In particular, the user requirements regarding the user interaction with the MiniStor system are first identified by applying well established techniques of agile development, i.e. by describing "User Stories" and "Use Cases". This methodology enables the determination of the key content features of the User Interface which are grouped in different categories based on their functionality. According to the current analysis five categories are defined and concern the overall state of the building's electric and thermal microgrid, specialized data analytics, the optimization and control capabilities, the energy prediction and the demand-response events, and have been designed as separate tabs allowing an easy navigation in the User Interface functionalities. A first design of the interface and the aforementioned tabs is also presented through mock-ups. Finally, the user evaluation of the proposed design is included that in general reveals a wide acceptance of its features and provides useful suggestions for further improvements.	
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Table of Contents

List of Tables

List of Images

1 Introduction

This document is the second deliverable, in chronological order, for the WP7 and it is the first of two related deliverables of Task 7.1. The Design and Validation task follows the Ministor development respectively at pre-demo site (M9) and at demo site (M45).

The scope of this first period of task 7.1 is to implement and evaluate the design of MiniStor's user interaction, configuration, features and interfaces. As a first step, we needed to identify the different user roles, the means of interaction with the system, the monitoring and control operations that will be supported for the different users and define the different scenarios of use. The outcome of this design process was evaluated by a wide range of residential users, which could potentially be future MiniStor customers with specific expectations about the product and the features that it offers. The main objectives of this task were:

- to identify the user needs and requirements concerning their interaction with MiniStor system
- to perform the initial design of the user interfaces and features
- to evaluate the design

Results from this first stage will be applied to T2.1 "Identification of stakeholder requirements, market needs and barriers for implementation", T2.4 "Characterization of an interoperable and adaptable storage solution, easily integrated with PVT and other local RES" and incorporated in T3.1 "Initial dimensioning of the whole system according to general use typologies" and T5.1 "Design of the MiniStor control and self-optimization platform (Smart Home energy management system)" and T5.3 "IoT-platform for user interaction with system for operation and performance (visualizations, alerts, actionable devices, user interface)". Results will also help refine the message being delivered to stakeholders in WP8.

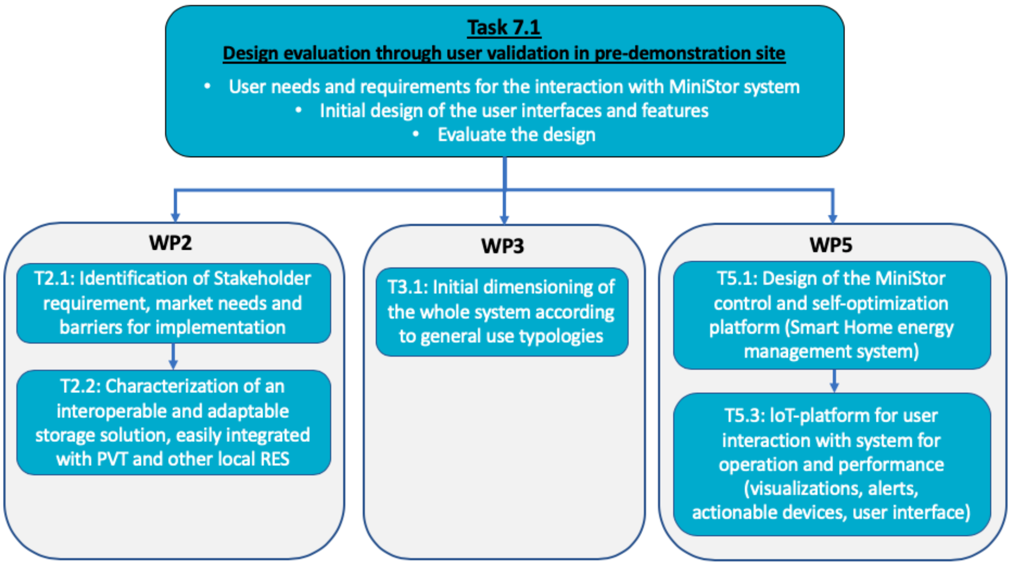

Figure 1 Task 7.1 connections

In the following chapters we present:

- the Methodology that was followed for both the user requirements definition and the user evaluation is described
- the User Stories that have been identified are presented
- the Use Cases that have been identified are presented
- the design of the User Interface (UI) is presented through mock up screens
- the evaluation of MiniStor design from the users is presented and discussed
- the outcomes of this first stage of this task are given in the Conclusions

2 Methodology

The following methodology was used to better understand the needs and expectations of MiniStor users regarding their interaction with the system:

a) Identification of user requirements
b) Initial design of the system based on user requirements
c) Evaluation of the design by potential end-users

During this first period of the task, weekly discussions were held between the responsible partners, in order to analyse, work and advance on the task's objectives following well-structured methodologies for the Requirements, Design and Evaluation phases. The methodologies are described in detail in the following sub-chapters.

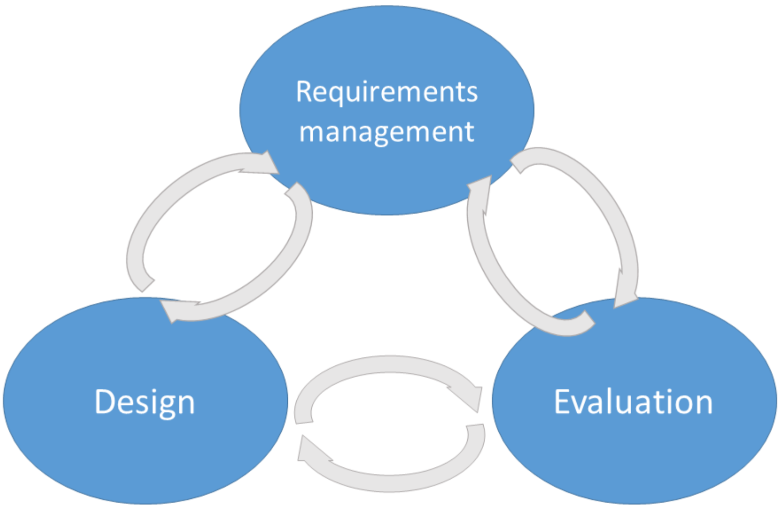

Figure 2 MiniStor design methodology of user interaction

2.1 User Requirements and Design Methodology

MiniStor aims to provide sustainable heating, cooling and electricity storage for new and existing residential buildings, by using solar-based renewable energy sources. In accordance to that, the project also aims to develop a human-centric system that provides a home energy management system, which is connected to Internet of Things (IoT) sensors and actuators for monitoring and control of different building and environmental parameters. MiniStor will provide a suite of software tools to the end-users (monitoring, control, prediction, demand-response, etc.), which will be accessible through a dedicated User Interface. The features that will be provided to the end-users needed to be carefully defined and designed in order to serve user needs and allow for energy efficient, environmentally friendly and automated buildings.

The definition of user requirements is a core activity that plays an important role in the development procedure and the success of the final product. As a preliminary step of this task we have examined different user requirement methodologies in order to select the most appropriate path for this task.

The most commonly used way of modelling requirements is by the definition of **Use Case** scenarios. The Use Case approach has been very successful the previous years, due to its impact on the whole development cycle, which assists in defining the application architecture and identify the different components of the system in the design phase. The use case is a procedure that describes how an actor is using the system and includes a main sequence of actions (success scenario), as well as one or more alternative paths. Use cases can be written in unstructured text or in the form of Unified Modelling Language (UML) diagrams, while quite often they conform to a structured template containing:

- Title,
- Goal,

- Actor(s),
- Preconditions,
- Main Success Scenario,
- Alternatives,
- Extensions etc. [2].

Technical terminology is usually avoided so that the use case is clear to customers, end-users and non-technical readers. For this procedure we have chosen to use a structured template for the definition of MiniStor Use Cases.

Early in 2001, the Manifesto for Agile Software Development was created by 17 people who met to discuss the future of software development. The manifesto was a short document that described the team's conclusions on how to develop and manage software in better ways, from which the Twelve Principles of Agile Software have emerged. Some of the principles include "to satisfy the customer through early and continuous delivery of valuable software" and "welcome changing requirements, even late in development". Capturing requirements in the agile world is usually made through User Stories, which is the smallest unit of work in the agile framework. While Use Cases focus more on the behaviour of the system, User Stories focus on "who", "what" and "why". Each User Story can be considered a thread through one of the use cases and can be expressed in a single sentence, using simple language [1]. In the following figure, User Stories' and Use Cases' main characteristics and differences are presented in a nutshell.

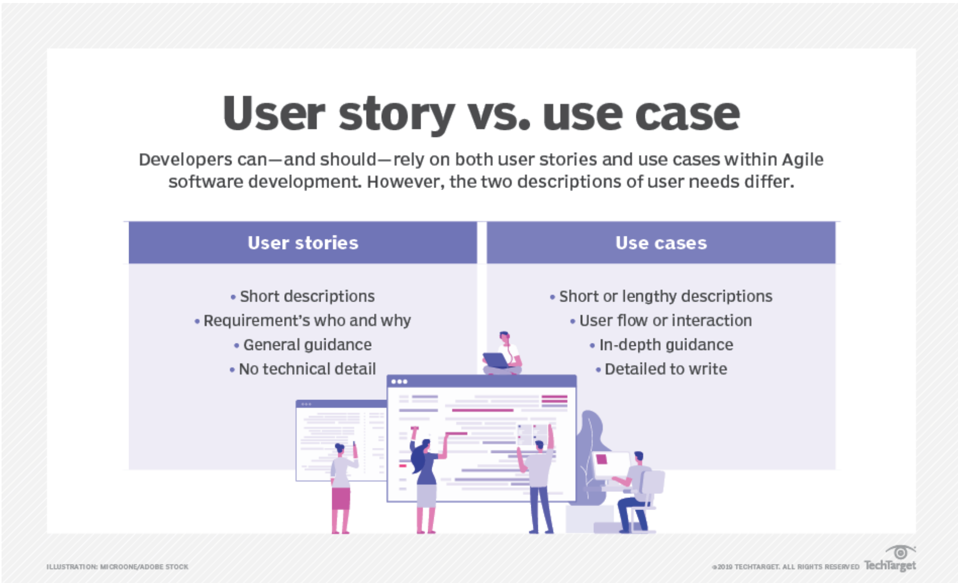

Figure 3 - User Story vs Use Case [7]

In Agile project management:

- User stories are short requirements or requests written from the perspective of an end user.
- Epics are larger bodies of work that can be broken down into a number of smaller tasks (called stories). A series of related and interdependent user stories makes up an epic.

In order to gather and organize the User Stories, we specified for each one the following fields:

#	User Type	Epic	User Story

Where user stories are usually expressed in a simple sentence, as follows:

"As a [type of user], I [want to], [so that]."

- "As a [type of user]": Who are we building this for?

- “Wants to”: Their intent, goal — not the features they use. What is it they’re actually trying to achieve?
- “So that”: What’s the reason?

Use Case models and User Stories are both very important techniques in the Requirement Gathering Process of software development [3]. When comparing Use Cases and User Stories it appears that User Stories are much simpler tasks than Use Cases, while there is a similarity between Epics and Use Case models. Users and Epics can be used to generate Use Case models.

At the same time, User interface prototypes, usually known as **mock-ups**, have proven to boost efficiency when capturing requirements of Web Applications [4], [5]. Mock-ups are valuable for developers and at the same time, fully understandable by end-users [6]. The mock-ups that we designed for MiniStor, originate from the User Stories and the Use Cases that we defined in order to capture the user requirements.

Before proceeding with the presentation of the Use cases, User stories and Mock-ups of the User Interface (UI), we need to present the potential end-users of the system that we have identified. The different types of users will also define the limits of the system. The Actor (as it’s called in Use Cases) or Type of User (as it’s called in User Stories) characterizes the role of an external entity of the system and is someone that interacts with it.

The Actors/Users that we have identified for MiniStor User Interface are the following:

- the resident of the apartment/building
- the building manager
- the maintenance personnel or technical manager
- the administrator
- the developer

Following the above steps the UI features were identified from the user stories, while possible interactions and functionalities were identified through the use case scenarios that were formed taking into account also features already identified in tasks of WP 2, 3 and 6. The first drafts of the MiniStor UI were designed in graphical form, with the intended colour schemes, and they incorporated basic functionalities and features identified from the user stories and use cases (for example, visualization of tariffs and energy consumption). The mock-up drafts were divided into different “screens” where such functionalities would be found.

In the next chapters we present the user stories and use cases that have been identified based on the desired functionality for each Actor/User, while the mock-up interfaces have been implemented with focus on the actual end-user/customer, meaning the resident and/or the building manager.

2.2 User Evaluation Methodology

The methodology used in this task for the MiniStor design data collection, follows the approach of a remote interview with potential end-users interested to improve their building or dwelling energy flexibility by an innovative solution for the energy management and storage. A questionnaire was developed considering both the use cases/user stories and the mock-ups evaluation.

The questionnaire was split into four main sections of questions:

- Background information
- MiniStor features and functionalities
- MiniStor Mock-ups
- Business opportunity

The questionnaire was circulated in order to reach a large number of stakeholders and collect a high level of information. This was realized through an online form which was distributed to a wide audience with different backgrounds. A total of 87 responses was received. A section of the editing version of the online questionnaire form can be seen in the next figure.

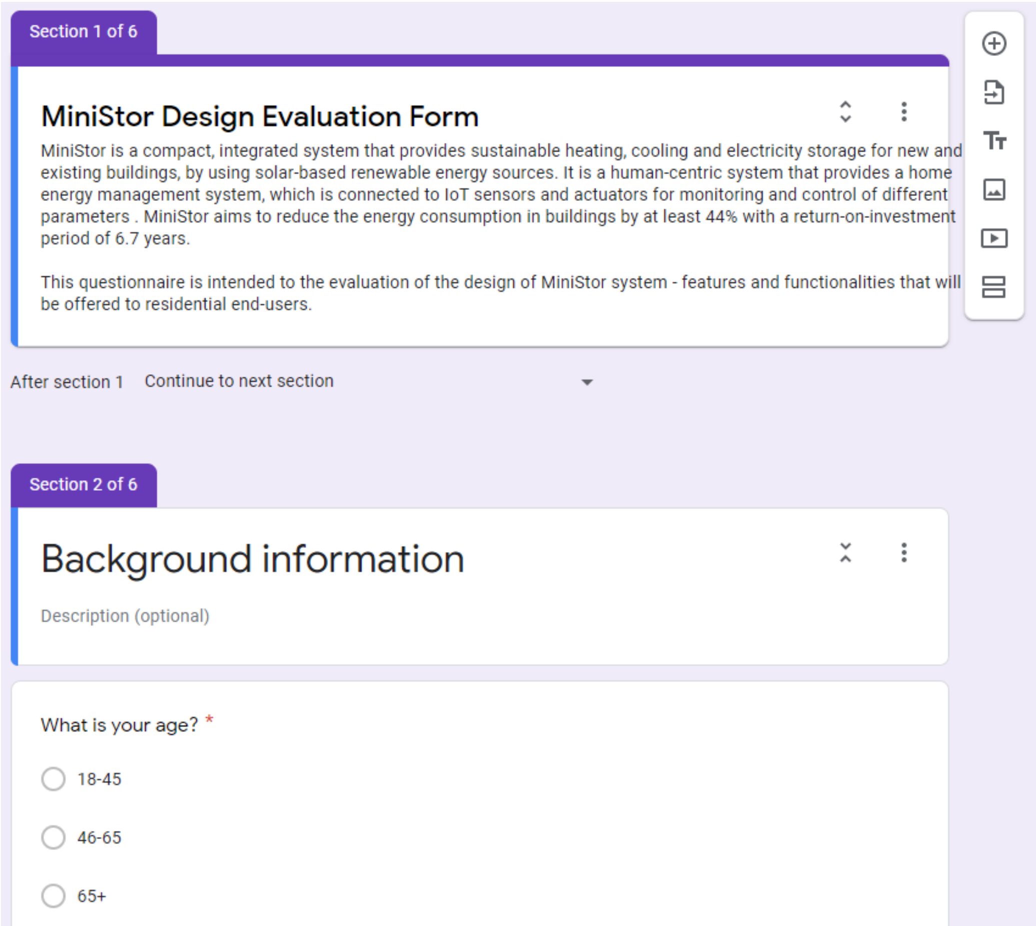

Figure 4 A section of the MiniStor Design Evaluation Form

The evaluation process can be summarized in four main points:

a) Identification of questions for the design evaluation

Through a brainstorming session that involved the partners participating in the task, a series of questions were formulated in order to know more about the characteristics of potential users, their preferences regarding thermal and electrical storage systems, and to provide a first evaluation of the interface design. The intent was to investigate expectations and needs. The majority of questions followed the close-end type in order to facilitate both answering and data collection, while others required an open type of answer, such as describing any energy improvements made to the respondent's dwelling.

The first block of questions included a brief demographic description of the respondent (age and gender), the time in years they have resided in their dwelling, and the number of occupants they live with. General knowledge was gauged with specific questions on energy storage and fluency in English. This last question was made in order to see if the respondents could easily participate this survey, since it was conducted in English. A further question asked participants to detail any energy improvement made to their dwelling, in order to understand if they are partial to perform energy improvements and which type of energy improvement is done more frequently.

In the second part of the questions, participants were asked which specific parameters and functionalities they would prefer to monitor in the interface, and which ones to control. They were also asked on other related functionalities such as the presence or absence of guided help during interface operation. This is due to the fact that in some systems that have intuitive operation or are well known, guided help is seen

as intrusive. Interest in active management of demand-response signals was also introduced in the questionnaire, to see if users would be willing to control manually or not this type of element. Finally, users were asked which would be their preferred device to use the interface, such as a personal computer (PC), mobile device or a screen on the wall. They were also asked if they would be willing to install and use such a system in their building, and the reasons for this.
In the third part of the questionnaire, participants were able to view the mock-ups of the interface and answer a series of questions about them, concerning their look and feel.
The last block of the questions is related to the business aspects of the product. They will be helpful for delivering the right message to the potential customers. The full questionnaire is presented in Annex II.

b) Circulation of the questionnaire among potential users

The questionnaire was published and distributed using Google Forms[1] platform. This ensured that it could reach the largest number of potential interested persons, and guarantee their anonymity. The questionnaire was promoted among academic and professional networks via postings on social media (MiniStor's website, LinkedIn and Twitter page) and through email distribution lists. Recipient of the social media and emails were asked to re-distribute among their contacts as well.

c) Analysis of responses

The results collected through the questionnaire are presented in the form of graphs (bar, pie) for better presentation of data, while open-ended responses were studied for trends or categories, such as classifying the type of improvements proposed.

d) Derivation of conclusions

The analysis of responses gives meaningful results and allows for the validation of the initial design while feedback can lead to improvements and new features. The interface design will continue based on the feedback received and will be the main input for the UI implementation in T5.3.

3 User Stories identification

In the following table the User Stories that we have identified for the MiniStor user interaction with the system are presented. As described in the methodology, User stories are usually expressed in a simple sentence, as follows: **"As a [type of user], I [want to], [so that]."** New User Stories can of course be added in this list throughout the course of this project, according to the feedback we will receive from different stakeholders. User Stories that are found to be related are grouped in larger bodies of work, called Epics, which we have identified as the following:

- Administration
- Monitoring (Status, Data Analytics)
- Control
- Prediction
- Demand Response (DR) Events
- Alerts/Notifications
- Maintenance
- KPIs monitoring

For each type of user, we have tried to identify his/her needs and wants in order to express them in the form of User Stories. Most of the stories concern the roles of Resident and Building Manager, which are the main potential customers of the system.

[1] https://en.wikipedia.org/wiki/Google_Forms

	User Type	Epic	User Story
1.	Resident/Building Manager	Monitoring	As a user I want to view the temperature of each room in my apartment, so that I can decide when to turn on the heating.
2.	Resident/Building Manager	Monitoring	As a user I would like to see the temperature or humidity data in the past. E.g. in a given day, so that I can monitor the conditions of my building.
3.	Resident/Building Manager	Monitoring	As a user I would like to see the energy consumption of the building, so that I can monitor its behaviour.
4.	Resident/Building Manager	Monitoring/Data Analytics	As a user I would like to see the monitoring data in the form of graphs so that it is easier to observe the state in a certain period.
5.	Resident/Building Manager	Monitoring/Data Analytics	As a user I would like to choose the period for which I would like to see the data.
6.	Resident/Building Manager	Monitoring	As a user I would like to see the stored energy amount in the MiniStor system, so that I'm fully aware of the system's condition
7.	Resident/Building Manager	Monitoring	As a user I would like to see if the battery is charging or giving energy to the building, so that I'm fully aware of the system's condition
8.	Resident/Building Manager	Monitoring	As a user I would like to see the status of my building's conditions in a summary, so that I can easily grasp the overall picture of its condition.
9.	Resident/Building Manager	Monitoring	As a user I want to know what portion of energy is covered by the Ministor System and what portion is covered by the grid or by another fuel (for thermal).
10.	Resident/Building Manager	Monitoring	As a user I would like to see how much energy the system is importing/exporting to the grid as well as the daily imported/exported energy so that I can understand the electricity energy balance of the building.
11.	Resident/Building Manager	Monitoring	As a user I would like to see how much electrical and how much thermal energy is produced by the PVTs, so that I'm fully aware of the system's condition
12.	Resident/Building Manager	Control	As a user I want to be able to schedule which hours of the day the heating/cooling will be turned on or off, so that I can save energy when away from home.
13.	Resident/Building Manager	Control	As a user I would like to set the desirable building temperature for

			tomorrow or during bedtime, so that I can reduce energy costs, while maintaining comfort.
14.	Resident/Building Manager	Control	As a user I would like to be able to set my comfort levels and allow the system to automatically control the heating/cooling based on my previous behaviour and external weather conditions, so that I can allocate energy resources in an optimum way.
15.	Resident/Building Manager	Control	As a user I want to be able to choose if the energy from the Ministor will be used for space heating or hot water.
16.	Resident/Building Manager	Control	As a user I would like to be able to create a weekly heating schedule, so that I don't have to worry to manually operate the system.
17.	Resident/Building Manager	Control	As a user I would like to be able set a different heating/cooling schedule when I am away from home.
18.	Resident/Building Manager	Control/Notifications	As a user I would like to be notified of any unusual energy consumption while I have informed the system I am away from home.
19.	Resident/Building Manager	Notifications	As a user I would like to be able to define alert levels e.g. the battery storage is lower than x, so that I can be notified
20.	Resident/Building Manager	Notifications/Maintenance	As a user I would like to be notified if some part of the system needs maintenance, so that I can contact maintenance personnel to replace it.
21.	Resident/Building Manager	Notifications	As a user I would like to get notifications in case of a problem identified in the system, so that I can avoid any accident.
22.	Resident/Building Manager	Notifications	As a user I want to be notified if the energy stored in the PCM vessels is lower than a predefined level.
23.	Administrator/Building Manager	Notifications	As a user I want to be notified if the ambient conditions are close to the operational limits of the system, so that I can perform any precaution measures.
24.	Administrator /Technical Manager	Administration / Notifications	As a user I want to define different alarm levels for the safety critical parameters of the system and receive notifications so that I can take appropriate actions for maintenance or emergency.
25.	Administrator	Administration	As a user, I want to be able to add or remove buildings in the IoT platform, so that I can handle the MiniStor infrastructures.

26.	Administrator/Building Manager	Administration	As a user I want to know the value of critical operational parameters of the system (water temperature from PVTs, TCM pressure / temperature, NH3 level in the liquid tank) and the different alarm levels related to the operation of the system
27.	Administrator/Building Manager	Administration	As a user I want to know when the TCM unit is connected to the other subcomponents (NH3 evaporator, condenser) and what is the current state (idle, charging, discharging)
28.	Resident/Building Manager	Prediction	As a user I want to be notified about the DER forecasts of the following day, so that I can schedule some of my loads.
29.	Resident/Building Manager	Prediction	As a user I want to know how close was the actual production of the system comparing to the predicted consumption for that day.
30.	Building Manager	Prediction	As a user I would like to be able to view the prediction for both electricity and thermal energy production and consumption in real time compared to the actual values.
31.	Resident/Building Manager	Notifications/DR Events	As a user I want to be notified about the electricity price signals, so that I can reduce the electricity costs
32.	Resident	Control/DR Events	As a user I would allow me schedule to accept or deny demand response events coming from the electricity aggregator, so that I can reduce the electricity costs.
33.	Resident	Control/DR Events	As a user I would like be able to see past, current and future incoming DR events so that I can schedule my consumption.
34.	Resident/Building Manager	Maintenance operation	As a user, if a fault develops, I would like to know where it is located, and how to describe it to the repair technician
35.	Maintenance personnel	Maintenance operation	I would like to have a specific GUI that can guide me through the system faults and what needs to be changed
36.	Resident/Building Manager	KPIs monitoring	As a user, I want to view the energy savings for my building so that I can compare with prior to MiniStor installation period.
37.	Resident/Building Manager	KPIs monitoring	As a user, I want to view the CO2 emissions of my building so that I can see how environmentally friendly it is.
38.	Developer	Programing	As a developer I would like to be able to retrieve data through an API for a certain device and time period.

39.	Developer	Programing	As a developer I would like all the data to have the same time format (e.g. UTC) so that there is a common convention

Table 3-1 MiniStor User Stories

4 Use Cases identification

For the description of the MiniStor Use Cases, we have created the template which is presented in Annex I. The scope was to describe use cases in a common format, following the patterns found in the relevant literature. Many of the user stories described in the previous chapter express desirable features that are mentioned in the Basic and/or Alternative Paths, and are exploited by the user in order to interact with MiniStor system.

The main Use Cases that have been identified for the MiniStor UI are described in detail and presented in the following tables:

Use case Title	UC1: Regular weekday usage of the MiniStor system in heating season – Automatic Operation
Description/Goal	How to efficiently operate the system, everyday practice
Primary Actor	Resident
Pre-conditions	- The system is installed at their house and is running. - There are interfaces at home (PC, smart TV, dedicated screen) and the user has a smartphone
Basic Path/Success Scenario	1. The system is set to Automatic mode for heating. 2. Usually the night temperature is lower than daily temperature in a residential home. The system automatically starts to heat up the building before the people get up (around 5-7 am). 3. On the weekdays the people leave home for many hours, so there is the possibility to reduce the indoor temperature set points for heating to save energy. The calculations for the optimal set point are performed in the background the user can see in the UI the automatically set temperature. 4. The user visits the UI to monitor the temperature in the rooms and decide if he would like to switch from automatic to manual mode. He maintains the automatic mode and set the temperature comfort levels. 5. The user also checks if the energy that is used for keeping the house warm is taken from the energy storage or from the boiler. 6. Before the residents come home the system heats up the home again and maintains this temperature until they go to bed (10-12pm). The system performs these decisions based on the user's comfort levels.

	7. During night time the set temperature is reduced automatically based on outside temperature and user's comfort levels.
Alternative Paths	If the user/resident do not want to run in automatic mode, he/she has the opportunity to set the system to manual control. In this case he or she can determine the desired temperature in manual settings.

Table 4-1 UC1: Regular weekday usage of the MiniStor system in heating season – Automatic Operation

Use case Title	UC2: Regular weekday usage of the MiniStor system in heating season – Manual Operation
Description/Goal	The family members are going to leave the house in the morning and arrive back in evening. During the time they are at home the heating system provides a little higher (comfortable) temperature, and the time they are out of the house or at night the system saves energy by reducing temperature.
Primary Actor	Resident
Pre-conditions	- The system is installed at their house and is running. - There are interfaces at home (PC, smart TV, dedicated screen) and the user has a smartphone
Basic Path/Success Scenario	1. The user has set the manual mode for heating. 2. The resident can access the MiniStor user interface and create a heating schedule for his home according to his/her preferences. 3. During the time that nobody is at home the user decides that the system will reduce the temperature to a specific set point and for a specific duration. 4. The user choses a higher temperature during evening. 5. This schedule is set from Monday to Friday. 6. The user can change the schedule and add more heating time slots.
Alternative Paths	There are buildings that are well insulated or the temperature difference is quite small and by so there is no significant energy that can be saved by reducing temperature. In this case it is easier to keep the same temperature throughout the day.

Table 4-2 UC2: Regular weekday usage of the MiniStor system in heating season – Manual Operation

Use case Title	UC3: University dormitories building management
Description/Goal	How would the MiniStor system, handle a long period of absence of a student
Primary Actor	Student, resident of DUTh's dormitories
Pre-conditions	The system is installed at the machinery room of the building. Through extensive pipework, the thermal and cooling energy will be transferred to the student's dorm. The student leaves for holidays (~14 days). The thermostat is set to a

	specific temperature and the MiniStor system should maintain the pre-defined temperature for the whole number of days.
Basic Path/Success Scenario	1 – The system is informed of the away days of the student. So does the building manager 2 – The room's monitoring system can be accessed through the UI and the manager can remotely modify the thermostat's pre-set temperature. 3 – While away, a case of emergency occurs, the building manager is authorized to enter the premises and to properly ventilate the room. 4 – The system, in the "away mode", is monitoring the temperature of the dwelling. If an unusual drop of the temperature is detected, the student is informed by a notification, that he might have left a window open. 5 – The student forgets to inform the system of his return. The system detects an increase in the electrical energy consumed, via the electrical energy meter, and sends a notification. 6 – The student can monitor the energy consumption of his apartment while away. 7 – A case of overheating or overcooling occurs due to a malfunctioning thermostat, the system notifies the student and the manager via a message and stops operating.
Alternative Paths	o The system warns the student of its thermal/cooling capabilities and does not allow settings above/below its limits. o The system is able to send a message to the student and building manager in case of an emergency. o The student can set a time zone to the system, which operates the system at the pre-set hours and in a pre-set level of operation.

Table 4-3 UC3: University dormitories building management

Use case Title	UC4: The residential user goes on a trip
Description/Goal	How would it be if the owner goes away for some days
Primary Actor	Resident
Pre-conditions	- The system is installed at their house and is running. - There are interfaces at home (PC, smart TV, dedicated screen) and the user has a smartphone
Basic Path/Success Scenario	1- A winter day the user wakes up and home is still warm. User gets a reminder from their smartphone that a trip is coming up so there will be no one at home for the next days. 2- The user sets the "away" mode in the MiniStor User interface. 3- User forgets and goes to work.

	4- On return, and when lights turn on, interface on hallway reminds the user that the away mode is set for today but energy consumption is detected at home. 5- The user updates the "away" mode schedule by stating the specific days and time that he will be away. 6- The system provides its usual discharge for that night. 7- After the user leaves for the trip, the system goes on standby and keeps only vital functions and minimal charge not to have a hard re-start. 8- Using weather forecast, the system decides on when to start charging the storage again. 9- User gets a notification on the smartphone on the actions being taken. User can decide if to cancel or move forward any of them. User decides to let the system take over. 10- The day before the user's return, the system charges in full mode and stores heat. 11- On the day of the user's return, the system greets the user and shows current temperature, relative humidity and any energy gains made during the absence. 12- Away mode is turned off and returns to usual day-to-day operation.
Alternative Paths	1. User does not bother to set the "away" mode – In this case the system will detect activity based on electricity consumption pattern 2. Due to the lack of information, and after a period of (4 days), if system does not detect activity, it will perform a full charge and discharge cycle in order to keep the property warm and prevent damage due to condensation. This will repeat every 4 days until user returns. 3. Alarms will be sent to the user regarding this to the smartphone. User will take action (or not). 4. If user chooses to ignore alarms, full cycling and backup warming will take place when activity is detected. User will still be able to see performance during the time away

Table 4-4 UC4: The residential user goes on a trip

Use case Title	UC5: Building manager checks MiniStor
Description/Goal	How would the building manager take care of the system
Primary Actor	Building manager in large residential complex
Pre-conditions	- The system is installed at various homes and is running. - Inhabitants have interfaces at home (PC, smart TV, dedicated screen) and in the user's smartphone.

	- Building manager has interface at office (PC) and in smartphone (building manager mode)
Basic Path/Success Scenario	1 – Six months' check-up 2– Building manager receives a few days before, notifications either in smartphone, Outlook or on PC that a check is upcoming for the MiniStor systems. The manager is kindly reminded on email on the contact numbers if he/she requests assistance. 3- The building manager goes to the machine room where the systems are installed. He starts the check of the first one. 4- A scheme of the parts is shown. If there is something not working, this is shown as a glowing circle over the affected part. The same is available on a screen on the unit, with similar or more specialized items, in case the manager forgot the tablet or mobile. 5- The manager can touch on the circle and gather more information. 6- The manager can also get information on parts that might be nearing the end of their useful life or that will need replacement before the next scheduled revision. 7- The manager can decide that the inspection is finished for the first unit and moves to the next ones. The process is repeated. 8- After finishing inspecting the units, the manager can view and print a report on the health of the units. If any of them is detected to need a replacement, the repair service is contacted automatically (this has been also done by the unit if it was detected beforehand). 9- The interface on the manager's phone will notify him/her when the parts are ready and can book a visit from the repair technicians. 10- The building manager gets a new Outlook appointment for the next check
Alternative Paths	1- Building manager ignores notifications and no check is performed – then notifications should be sent more often. 2- After a number of notifications, the repair service can be notified that the building manager is ignoring them and is advised on calling him/her. 3- Building manager skips one or more units – The interface reminds them to continue the check as soon as possible. 4- If there are items that need notice and building manager does not check them, then interface reminds to check them

Table 4-5 UC5: Building manager checks MiniStor

Use case Title	UC6: Monitoring electricity consumption
Description/Goal	The user wants to check his electricity consumption against his Grid suppliers bill
Primary Actor	Resident
Pre-conditions	1. The MiniStor system is installed and running 2. The user can access the interface through a pc or mobile 3. The user is aware of different modes of electricity supply
Basic Path/Success Scenario	1. The user can compare the electricity consumption from bill with the one monitored by MiniStor system e.g. dates and meter readings 2. The user can identify the contribution from each source towards overall electricity consumption through a summarized view of the energy balance. 3. The user can identify the cost savings from exporting energy to the grid. 4. The user can identify how much electricity and thermal energy was produced by MiniStor system for today 5. The user can identify how much energy was consumed from the battery.
Alternative Paths	Control console is linked direct to suppliers account to supply details of electricity consumed from grid and receiving information on pricing to produce bill from supplier.

Table 4-6 UC6: Monitoring electricity consumption

5 Design of User Interface/User Experience (UI/UX) through mock ups

Numbers in brackets correspond to the parts indicated in the next figure:

Key content features

The users should be able to:

- Monitor in real-time the **energy flow** circles of the house and the **states and status of the system components:** PVTs, electrical battery, thermal battery, connection to the grid and other connected energy generators such as natural gas combustor, biomass boilers etc. (1)
- Monitor in real-time **Outdoor Environmental Conditions** and indications of unusually deviated levels of temperature, humidity, wind (1)
- Monitor in real-time **Indoor Environmental Conditions** – temperature, humidity (1)
- **Control Temperature** remotely, physically, through schedule, either for the whole house or independently for each room **for manual heating/cooling system mode** (3)
- Monitor the efficiency of the system by viewing in real-time the **overall energy balance outcome in both energy terms and cost terms** (1, 2)
- Overview the system's efficiency by viewing **historical data** on electrical and thermal energy flow and environmental conditions (2)
- Get an insight about upcoming needs by viewing **prediction** on electrical and thermal energy production and consumption (4)
- Monitor **DR Events** (5)

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- Get **informative and alert notifications** for system errors, for upcoming switches between sources of energy (e.g. when battery level is low – switching to importing energy from grid), maintenance, operating alarms (ammonia leaks, critical temperatures / pressure of Ministor components) etc. (6)
- Monitor system activity derived from potential **DR Events** (1), get related informative notifications (6), and set DR availability schedule (3)
- Change **Temperature Comfort Zone** settings, through personal preferences **for auto heating/cooling system mode** (3)
- Change **Notification Settings** – setting on/off specific type of notifications, through personal preferences (7)

Based on the above requirements the suggested Tabs are as indicated in the figure below:

Tabs

1. Microgrid: overall information summarized and at-a-glance on the MiniStor and the rest of the features provided by the interface.
2. Data Analytics: real-time and historical information of the thermal, hot water and power flow while providing reliable information on the electrical and thermal energy consumption and production in kWh and cost and marginal system price.
3. Control panel: optimization and control of the temperature and HVAC control in real-time, overall and per-room with the possibility to schedule the work of the system depending on economic savings, habits and comfort.
4. Prediction: prediction of consumption and production one-day ahead, comparison with actual values in real-time and past predictions.
5. DR Events: analysis of demand response events that have occurred, are happening and will take place so the end-user can adapt to energy costs and peak-loads of production.

Microgrid (Home Screen)

This screen presents an overview of the overall status of the system with information that can be expanded throughout the different tabs on the interface. With understandable and reliable real-time data, the end-user can make a tailor-made decision on the functioning of the system depending on weather forecast, the current household conditions, the energy markets and demand-response. With this information in contraposition of the MiniStor storage, the end-use can clearly see the output and input of the thermal and electrical storage while analysing the input of the grid, the PVT and the thermal energy source (e.g. natural gas). This feature gives ´eyes´ to the end-user to see the overall system and take the necessary decisions in real-time or schedule them to optimize the functioning of the system based on comfort criteria, environmental impact and economical saving. In Figure 5, Figure 6, Figure 7 the mock-ups of the Microgrid tab are presented, showing different scenarios of use.

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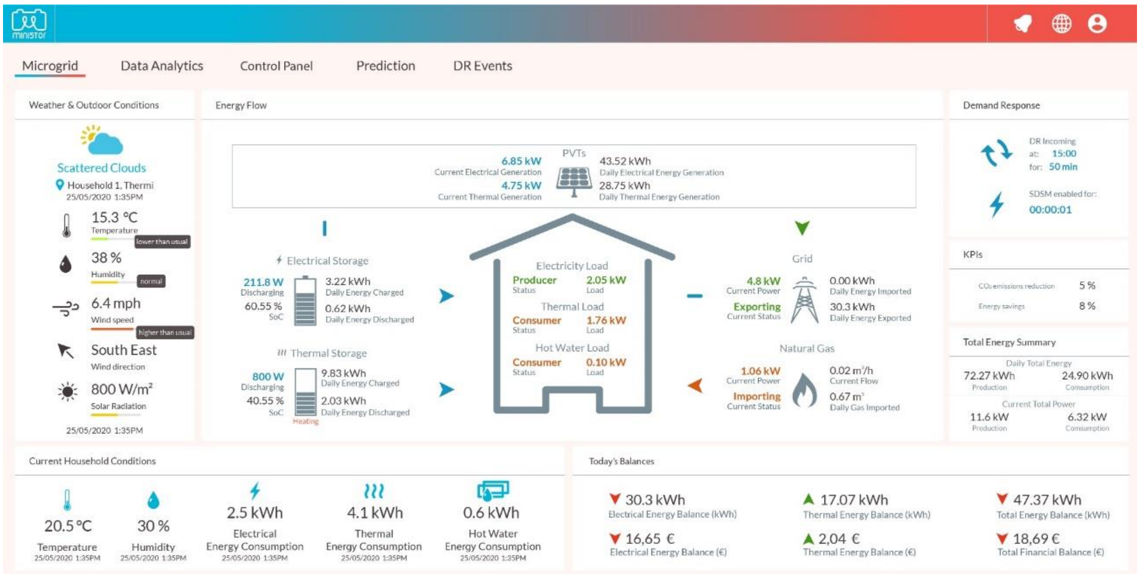

Figure 5 Home Screen - Exporting Electrical Energy, Consuming Electrical and Thermal Energy

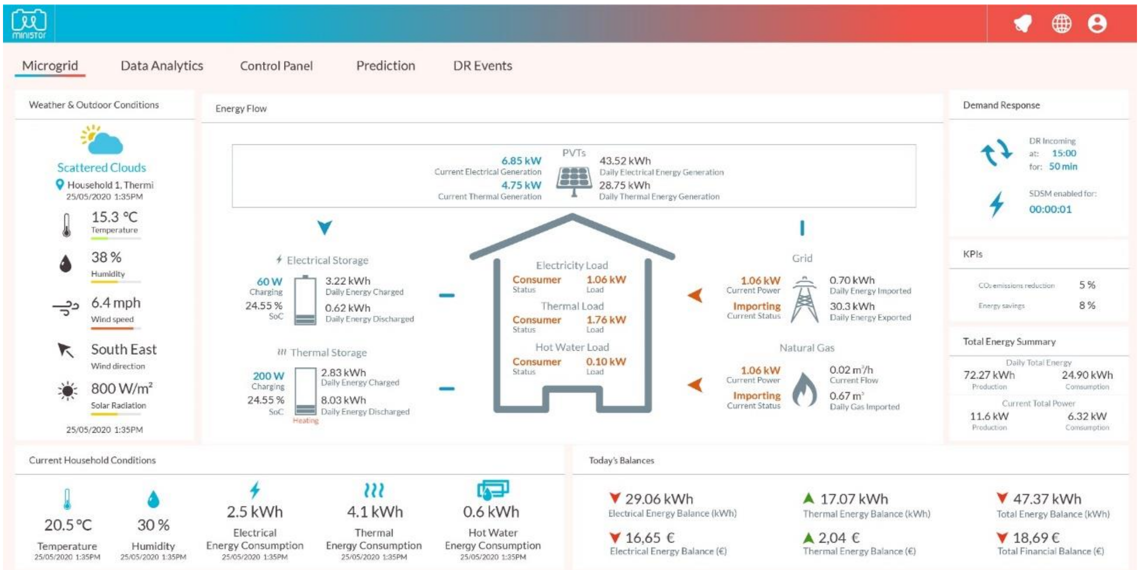

Figure 6 Home Screen - Importing Electrical and Thermal Energy, Charging MiniStor storage

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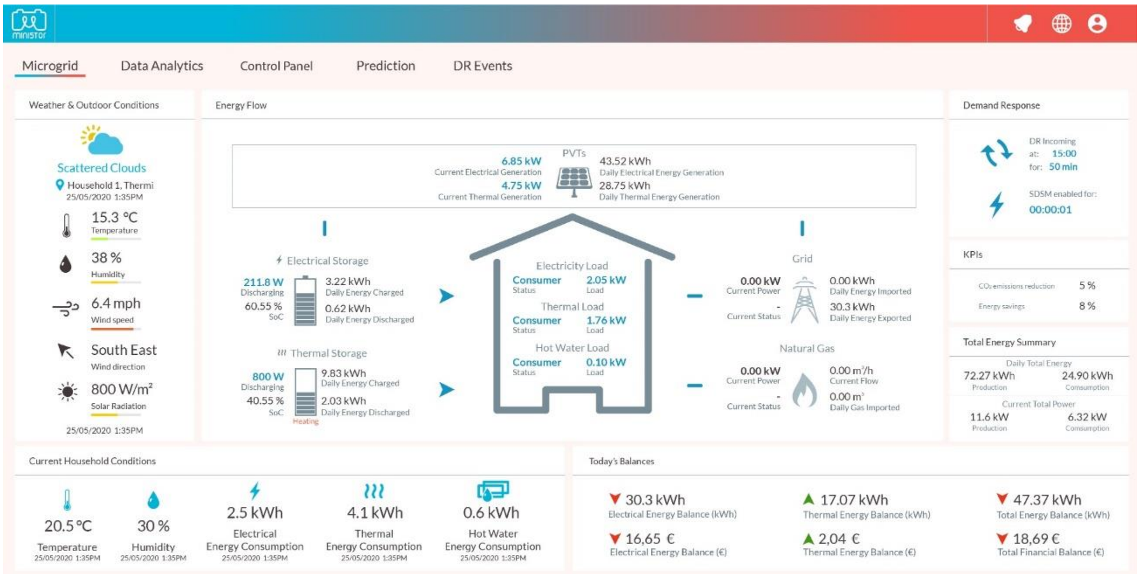

Figure 7 Home Screen - Consuming Electrical and Thermal Energy from MiniStor storage

Data Analytics

This tab gives the end-users real-time as well as historical information on the overall thermal and electricity production and consumption in terms of kWh and price as well as power and thermal flows and marginal system price. This allows the end-user to modify his/her behaviour and analyse the energy market wholesome to create patterns of use that can be scheduled, to optimize the system workload and ensure the economical savings while minimizing environmental impact. With comparable graphics (Figure 8) the information is presented in an easy and understandable manner feeding the rest of the features in the interface.

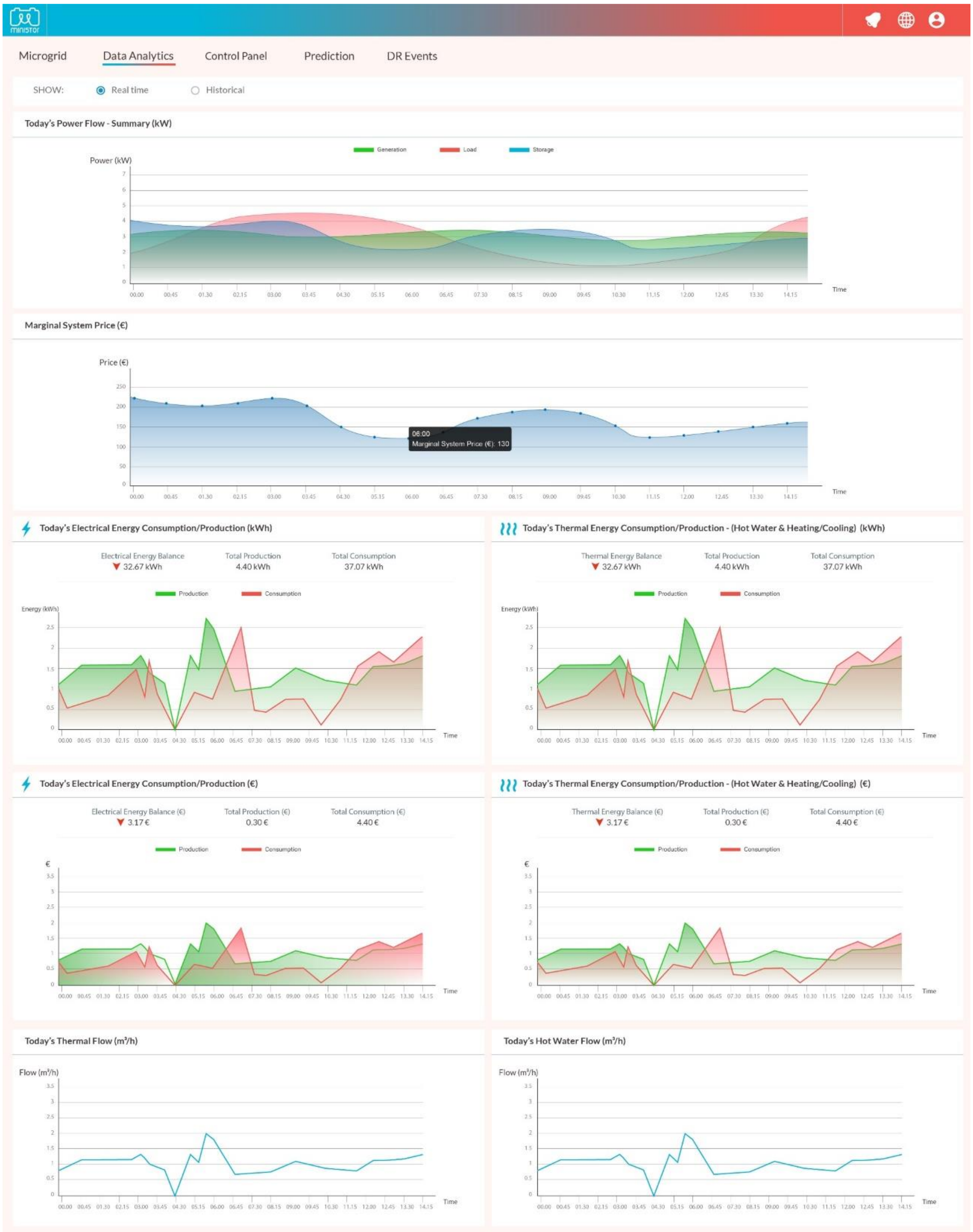

Figure 8 Data Analytics

Control Panel

This tab is dedicated to the controls that can be performed by the user. The MiniStor user can mainly control and schedule two aspects: temperature set points and electrical flexibility of the household. With one look, the end-user is able to see all relevant information about the real-time temperature of its household, overall and per room and manually control the temperature set points (Figure 9). The interface allows the user to also set up a schedule of heating and/or cooling, depending on the user's preference and comfort. This allows different schedules to be used for weekdays and weekends, during the day or when being away, depending on the end-use behaviour and habits (Figure 11). At the same time the user

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is able to select the Auto mode (Figure 10) and allow the MiniStor system controller to decide on the best function of the heating/cooling system based on the user's comfort level and on outside weather forecast. The user is also able to schedule the electricity demand response events by accepting or rejecting an event coming from the electricity supplier. This interface aims to provide an easy and efficient way to control and optimize a household reducing expenses while also reducing environmental impact.

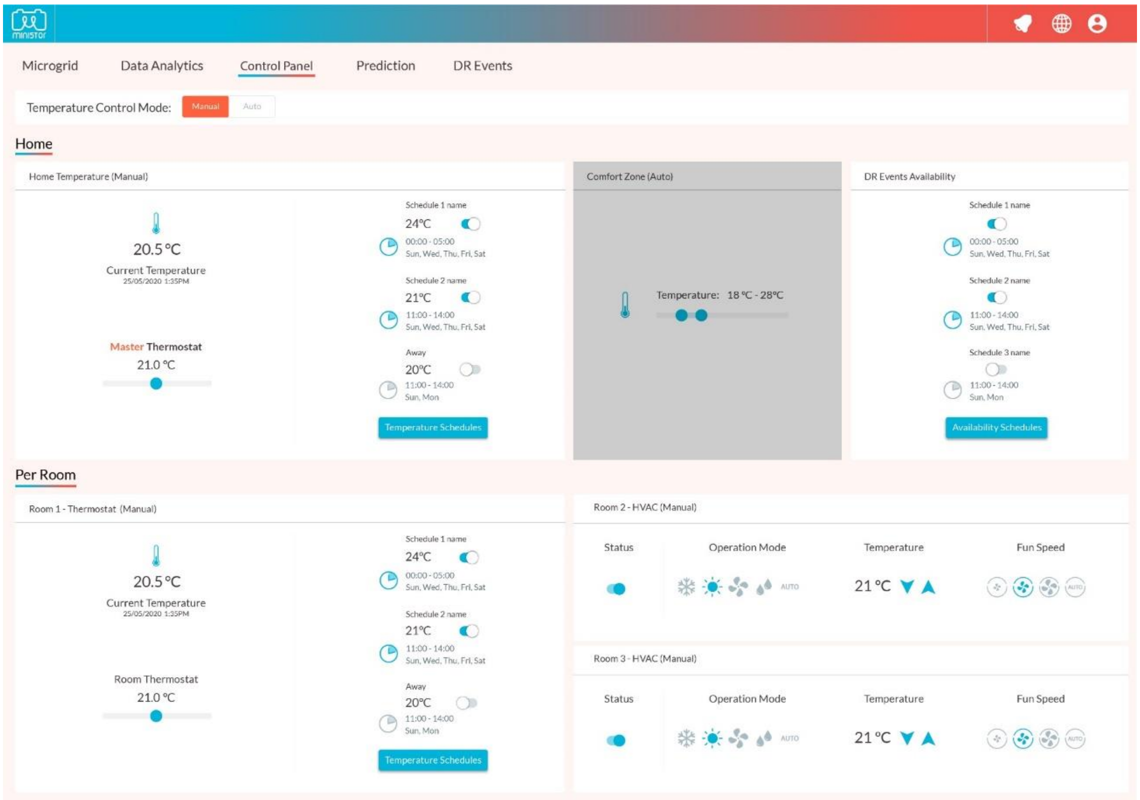

Figure 9 Control Panel - Manual Mode

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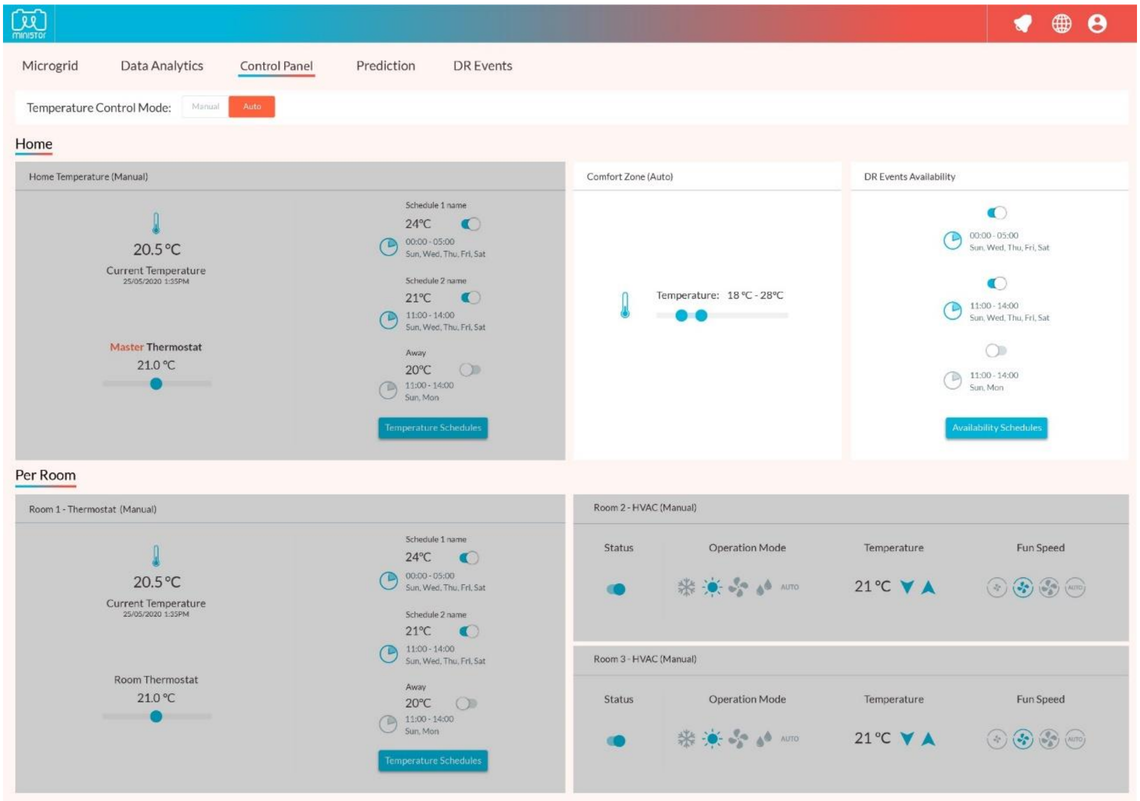

Figure 10 Control Panel - Auto Mode

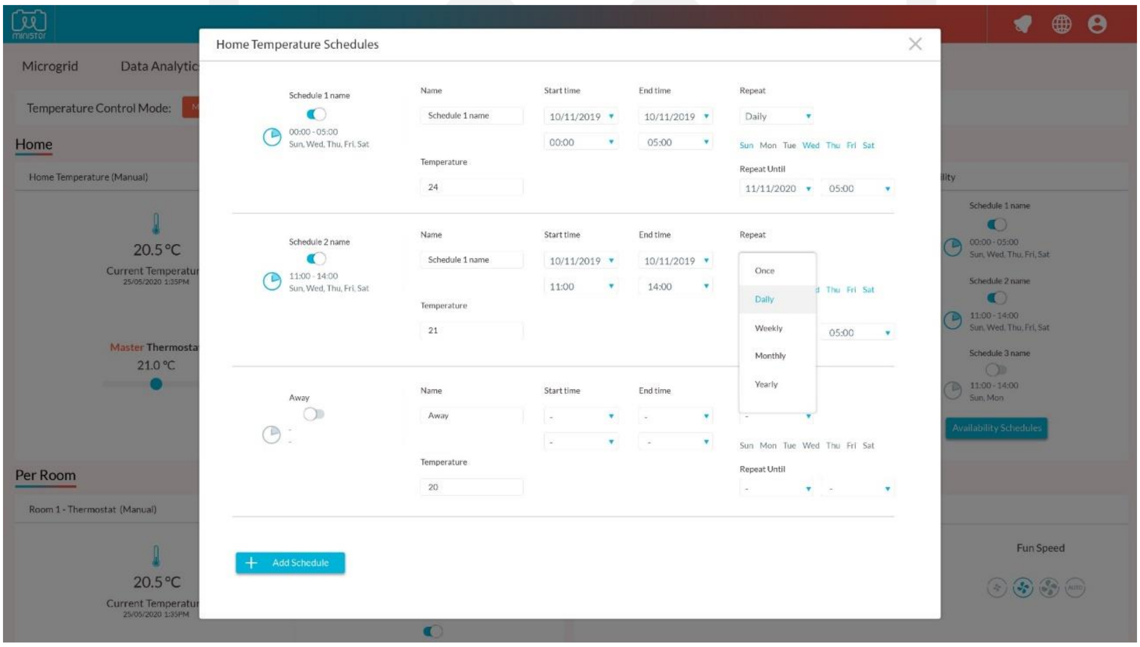

Figure 11 Control Panel - Heating/Cooling schedule

Prediction (One day ahead)

Performing a prediction of the energy production and consumption one day ahead and showing graphics that translate energy consumption and production into cost is a valuable feature for building energy management. This feature does not only show how much energy the end-user will consume or how much energy the PVTs will produce but it also helps to understand if a change of habits and shift of loads can help cutting off costs without an impact on the quality of the service. Prediction was mainly designed to address the needs for advanced energy management and is basically dedicated to energy experts and scientific pilots, although it could be of interest of residential users as well.

Figure 12 Prediction - One day ahead

Prediction (real-time)

This screen shows how much energy the household is consuming in real-time and compares it with the predicted values. This allows for a deep-understanding on the current energy behaviour of the end-user and allows for a decision based on the consumption behaviour, hence reducing total energy demand during peak times. Having information about the grid status can help end-users to plan their own energy consumption avoiding unnecessary costs. In short, this feature gives the end-user the tools to ´see energy´, where, when and how much is being used allowing the end-user to control and improve the consumption optimizing its system, saving money and avoiding waste in the process.

Figure 13 Prediction - Today (Real time comparison)

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Prediction (Historical)

The interface allows the evaluation of previous predictions showing actual vs predicted energy comparisons and the prediction error. This feature aims to unlock new possibilities for MiniStor's research on energy and also allow for better predictions in the short term. It also allows the end-user to identify consumption patterns overtime and change its consumption behaviour when and if needed.

Figure 14 Prediction - Historical data - Show prediction error

Demand Response (DR) Events

The Demand-response (DR) tab provides a tool for electricity consumers that aims to reduce consumption during peak periods where power prices are higher. In other words, this feature allows the electricity consumer to manage efficiently his/her energy use in response to the wholesale market conditions ensuring generation and economic savings. The end-user has access to information in real-time and for the next few hours/days, including details such as when the demand response event (DR event) is likely to occur and for how long it will last. End-users can then prepare to reduce their electricity consumption during those hours. They could do so by scheduling in their MiniStor interface the lowering of their consumption during that time period, or shift the consumption to either before or after the demand response event occurs.

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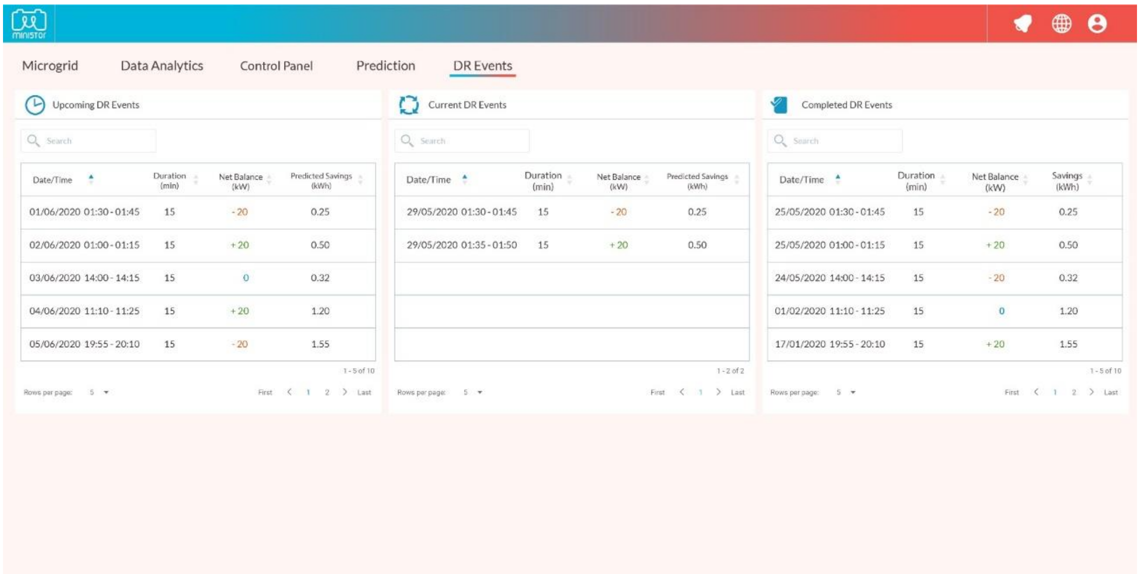


Figure 15 Demand Response (DR) events

6 MiniStor Design Wrap-up

In chapters 3, 4, 5 the MiniStor design for the user's interaction with the system was defined through different techniques: the User Stories, the Use cases and the interface mock-ups. All those three, express the definition of the user requirements of the system in different forms and are interconnected.

User stories express the smallest unit of work – usually a feature. A number of user stories were described according to what a user (based on his/her role) would like to have as feature of the system to interact with. As a next step Use case scenarios have been developed. The scenarios involve the description of more complex cases of the system's usage, where a number of different features is exploited and that's how they interconnect to User Stories. As a final step, the mock-ups were designed based on the needs that emerged through the User Stories and the Use Cases definitions. These relationships can be better expressed through an example, as shown in the following figure.

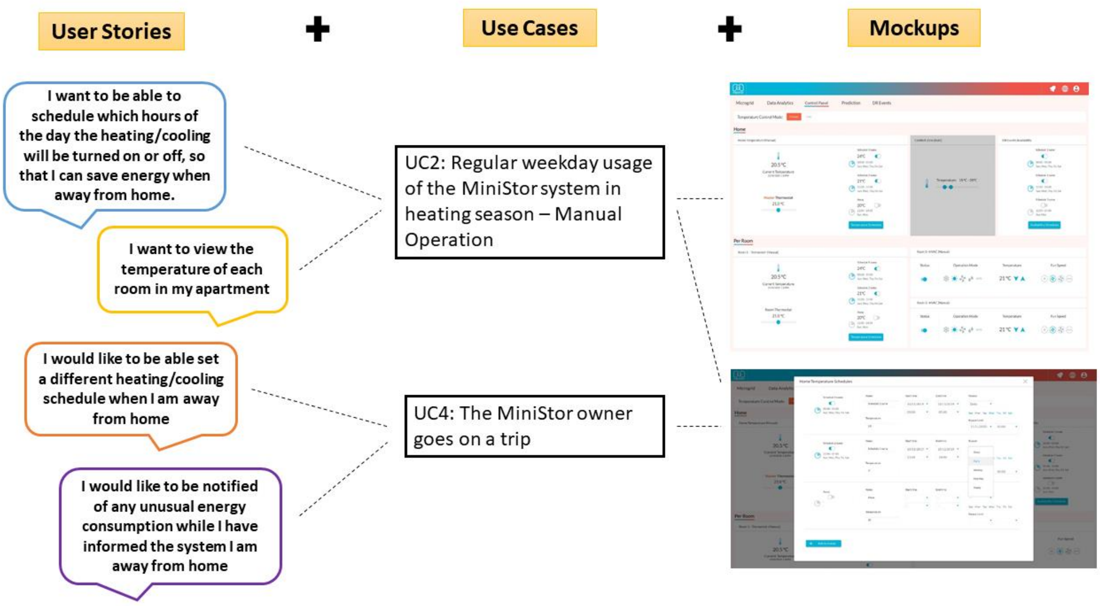


Figure 16 MiniStor Design Wrap-up

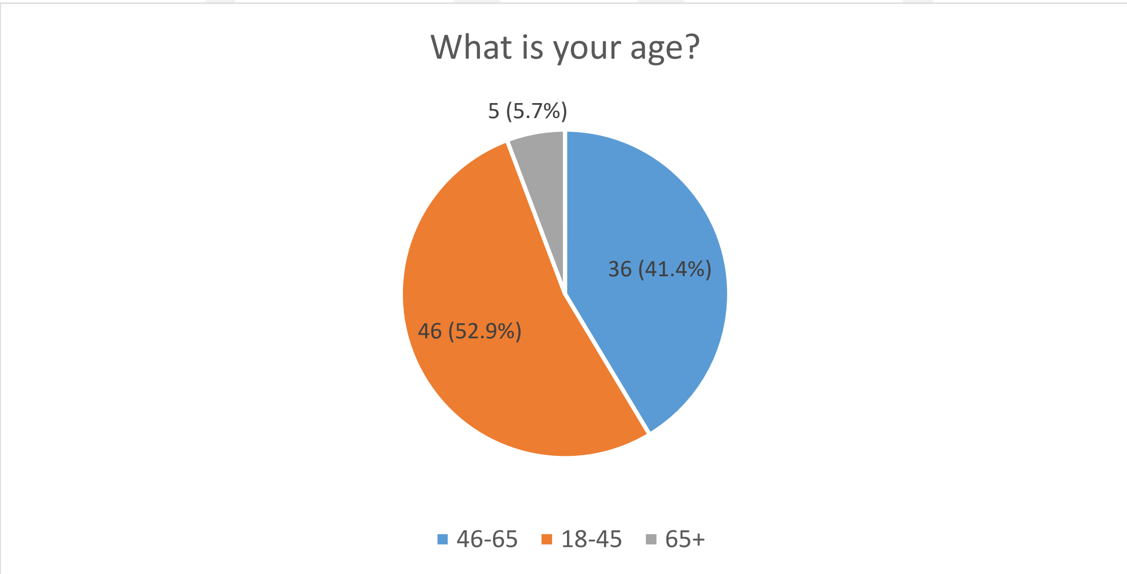
In Agile development, as mentioned in the Methodology chapter, it is important to involve the customer throughout the whole development activities of a product. Users' feedback should be always welcome as it is valuable in order to validate any process at an early stage and avoid taking the wrong path and trying to fix it when is too late. Thus, it is important at this first stage of the user interactions design to evaluate it by inviting potential end-users to participate and provide their opinion on it.

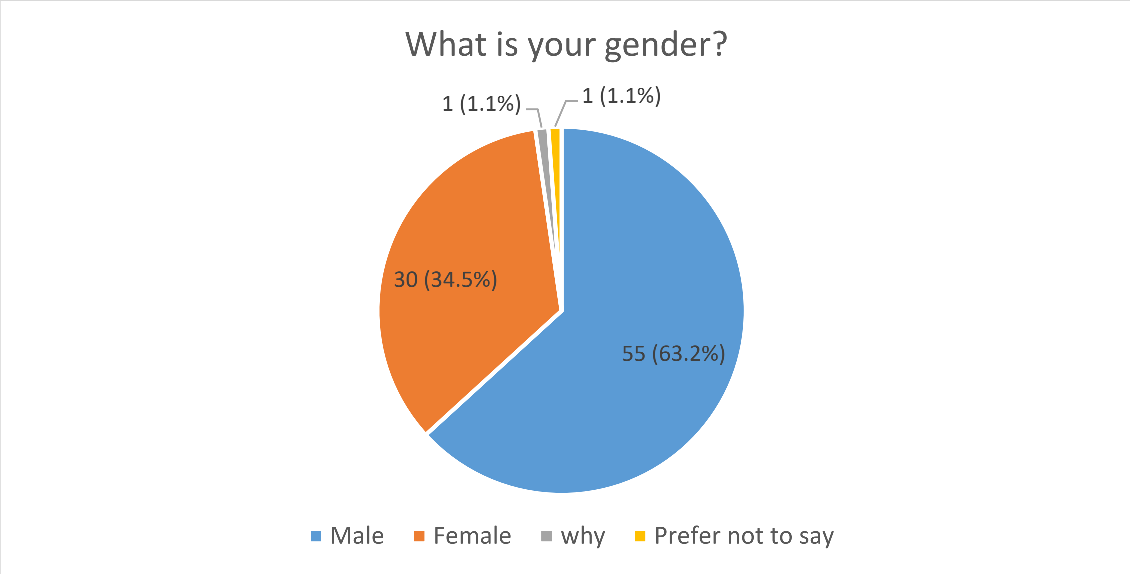
7 User evaluation of MiniStor design – Results and Discussion

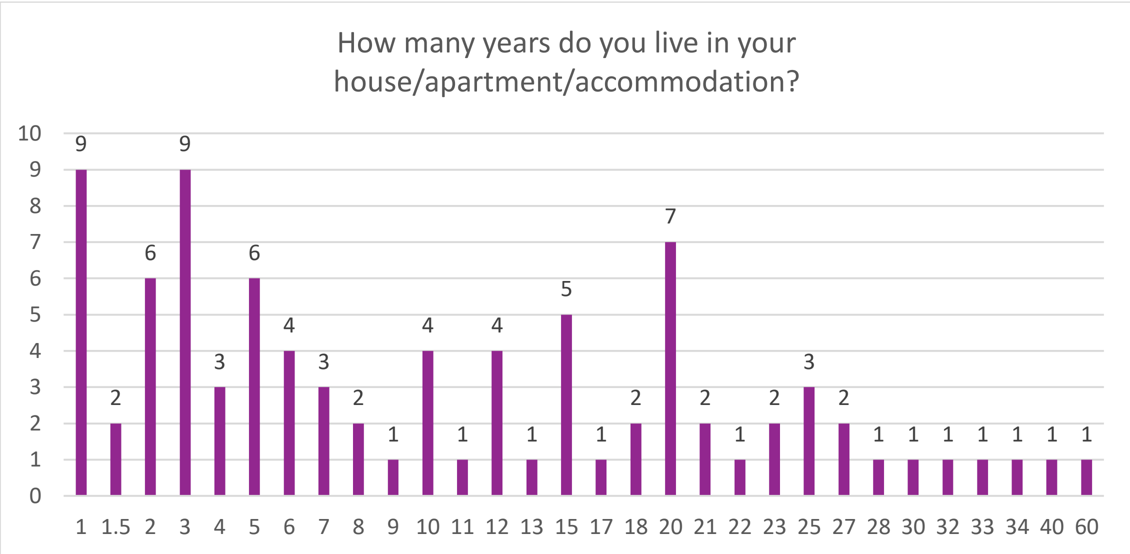
The evaluation of the MiniStor interface design was performed in the form of a survey/questionnaire of 26 questions (21 questions some of which are followed by a complementary explanatory question), which was distributed among potential end-users. A total of 87 responses was received. The raw answers were collected in csv format and the respective statistical analysis in the form of graphs or grouping of answers is presented below. The raw answers were kept internally for the record by the partner responsible for carrying out the survey.

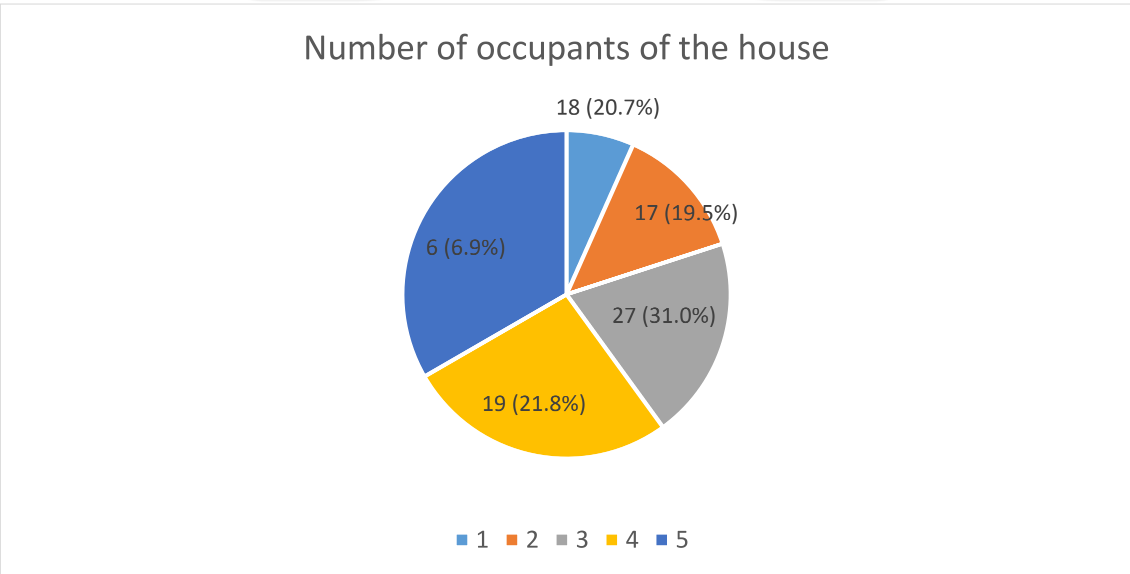
7.1 Background information

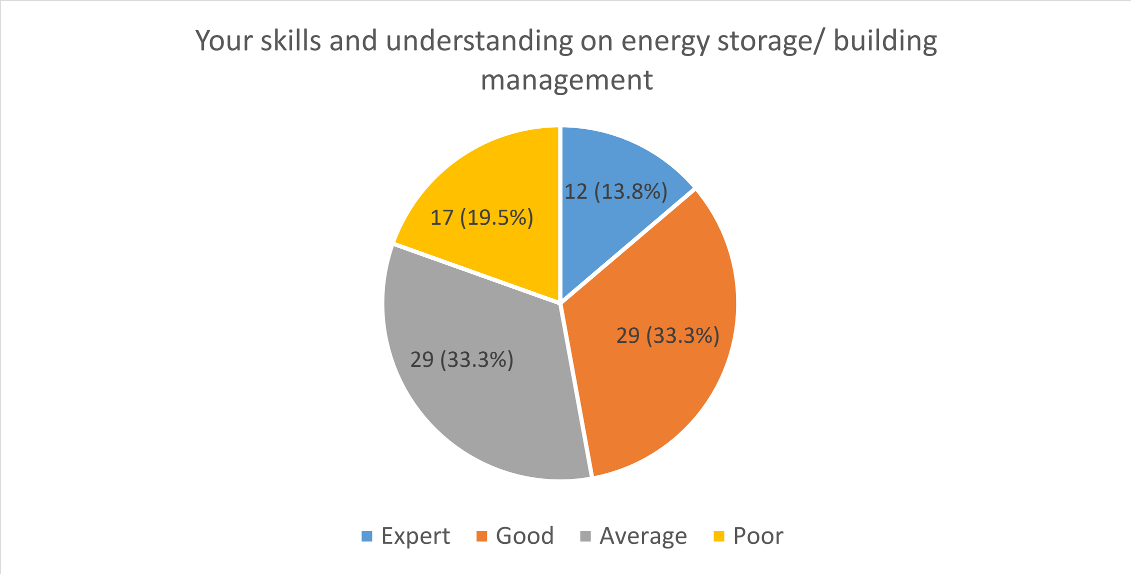
The first group of questions aims to identify background information of the respondents. The first two questions concern demographic information (age and gender), and show that slightly more men than women have answered the questionnaire, while most participants belong to the age groups 18-45 and 46-65. The respondents also show variability in the duration they have lived at their home and the number of occupants that live at their home. The respondents have also different knowledge backgrounds on the fields of energy storage and building management. The majority of them has fluency in English, thus they are able to properly understand and answer the questions. Another fact that was found from the survey, was that at least half of the respondents have conducted an energy efficiency improvement to their homes, such as addition of wall insulation or installation of solar panels. This shows that many of the respondents are concerned and motivated towards energy efficiency improvements and environmentally friendly solutions, which is also one of the solutions that MiniStor provides.
We estimate that this sample size is representative and has the right variance in background for conducting our survey. The results for this first group of questions is given in the form of charts below.

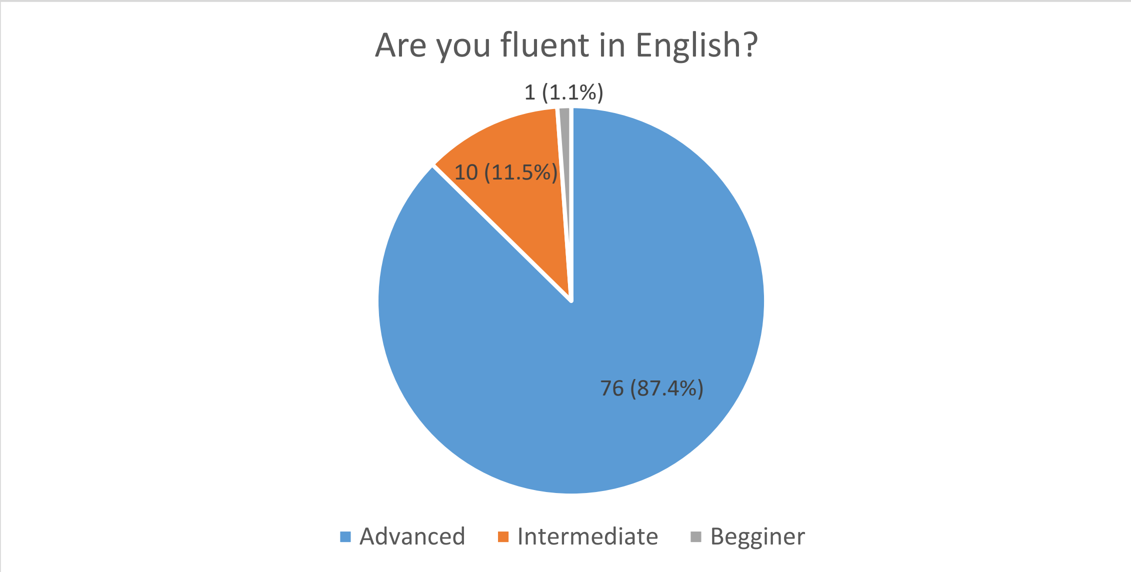


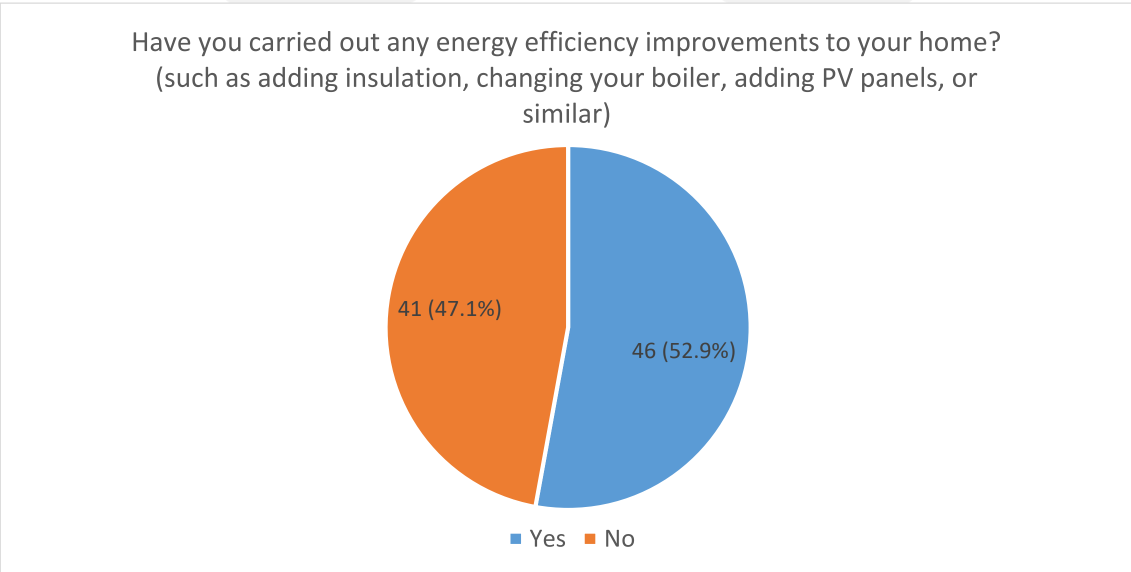

What is your gender?
1 (1.1%)
1 (1.1%)
30 (34.5%)
55 (63.2%)
Male
Female
why
Prefer not to say


How many years do you live in your house/apartment/accommodation?
10
9
8
7
6
5
4
3
2
1
0
9 2 6 9 3 6 4 3 2 1 4 1 4 1 5 1 2 7 2 1 2 3 2 1 1 1 1 1 1 1
1 1.5 2 3 4 5 6 7 8 9 10 11 12 13 15 17 18 20 21 22 23 25 27 28 30 32 33 34 40 60


Number of occupants of the house
18 (20.7%)
17 (19.5%)
27 (31.0%)
19 (21.8%)
6 (6.9%)
1
2
3
4
5


Your skills and understanding on energy storage/ building management
12 (13.8%)
29 (33.3%)
29 (33.3%)
17 (19.5%)
Expert
Good
Average
Poor


Are you fluent in English?
1 (1.1%)
10 (11.5%)
76 (87.4%)
Advanced
Intermediate
Begginer


Have you carried out any energy efficiency improvements to your home? (such as adding insulation, changing your boiler, adding PV panels, or similar)
41 (47.1%)
46 (52.9%)
Yes
No

If yes, please specify what was the improvement and when was this done?

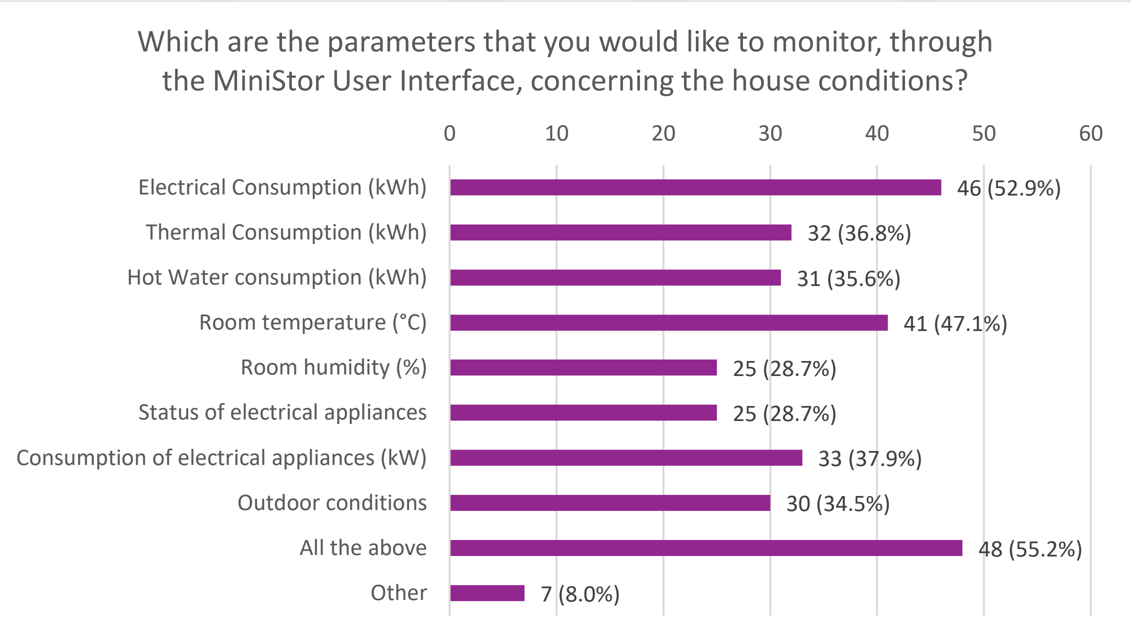
The answers included the following types of improvements. The answers are given in order, from the most common one to the least common answer, while most answers include more than one improvement:

- External or internal thermal insulation (e.g. Cavity Wall, floor) – 25 answers
- New boiler installation (e.g. natural gas, pellet) – 9 answers
- Installation of solar water heater – 8 answers
- New windows (e.g. PVC windows) – 7 answers
- Installation of Solar PV panels – 6 answers
- Installation of control heating system – 3 answers
- Replacement of all lamps with LED – 2 answers
- Installation of smart meter – 2 answers
- Thermal curtains -1 answer

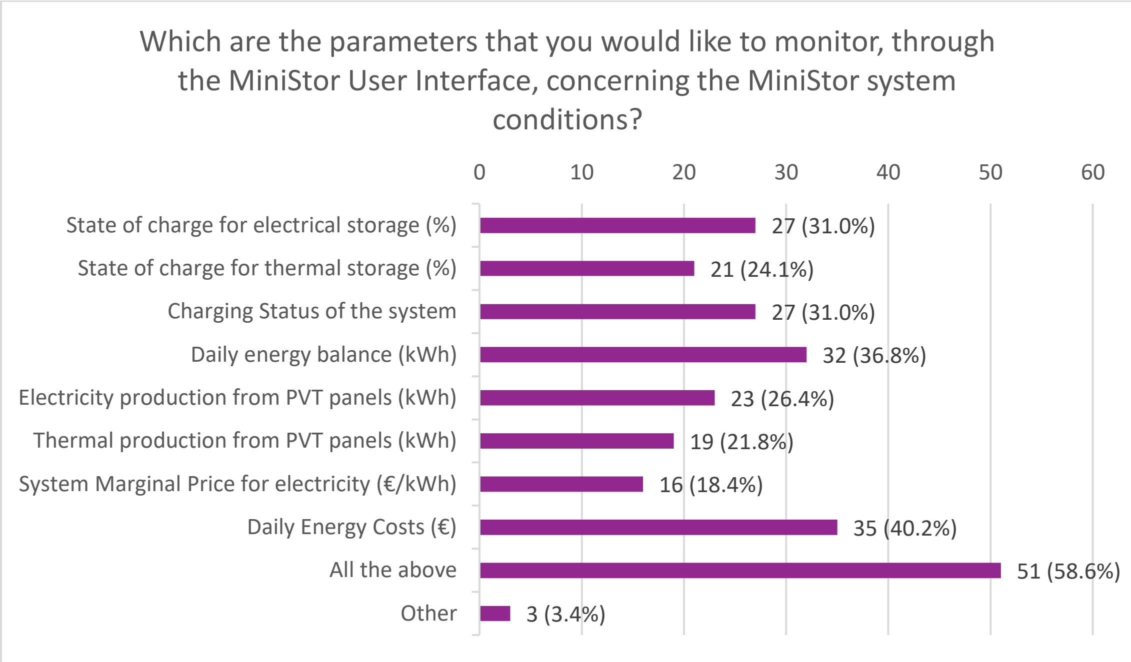
Some of the answers included also when the improvement was made, which ranges to a decade ago up to last year.

7.2 MiniStor features and functionalities

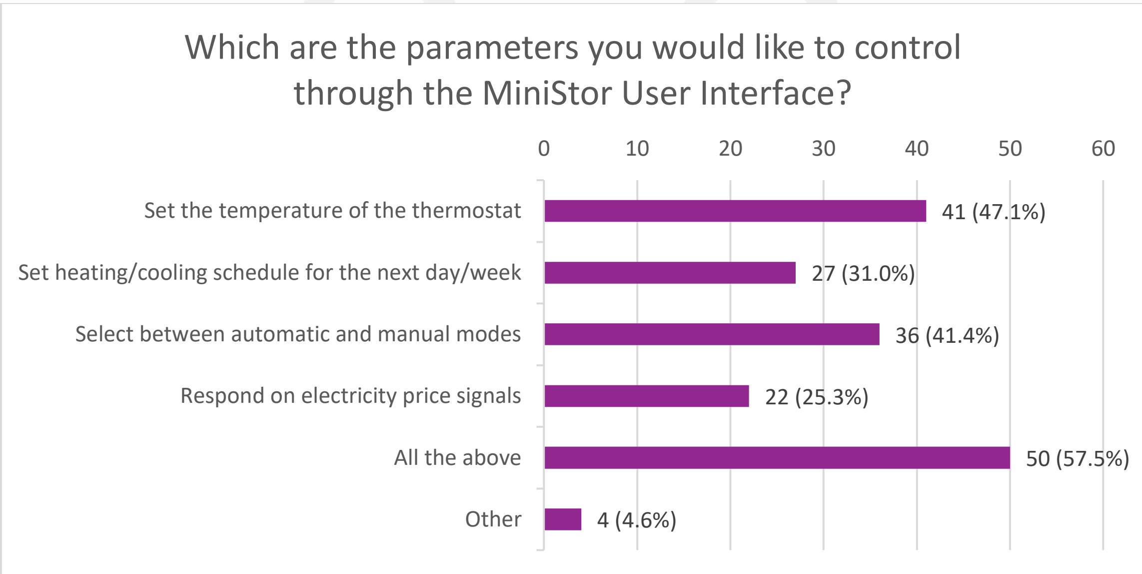
This second group of questions aims to validate the features and functionalities of the MiniStor system User interface as they were identified through the User Stories and the Use Cases. The results indicate that the control and monitoring parameters that we have identified were considered important for the User Interface. More specifically half of the respondents selected all features as important, while the rest showed preference on monitoring the electrical consumption of the building (46 of 87 or 52.9%), the room temperature (47.1%), the daily energy balance (36.8%) and the daily energy costs (40.2%). Moreover, they showed preference on control operations towards the heating/cooling temperature control (47.1%) while being able to switch between manual and automatic modes (41.4%). Another significant result is that 73.6% of the respondents would like to receive demand response (DR) event notifications in order to reduce their energy costs, while 78.2% would like to have a guided explanation of the control panel to better familiarize with the system. Concerning the most preferable device for monitoring and control of the system, the respondents have chosen the option of smartphone (since it is a more widespread technology today), followed by those who would also prefer a screen on the wall or to use their PC/laptop.



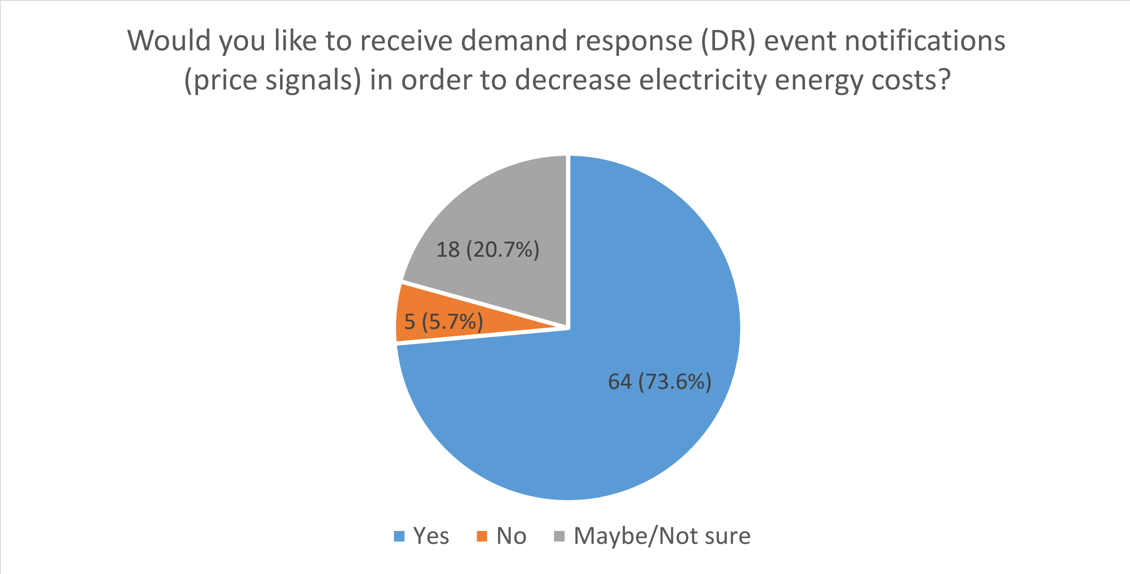
*Option "Other" included various answers: Alerts of deviations / high consumption / etc., Night-time and day-time electrical consumption, I already monitor all energy flows and actions in my house, I just want to know the device is on and working correctly, Internal Surface Temperature (to check condensation risk), subject to storage capacity, weather forecast, and cost of consumption daily

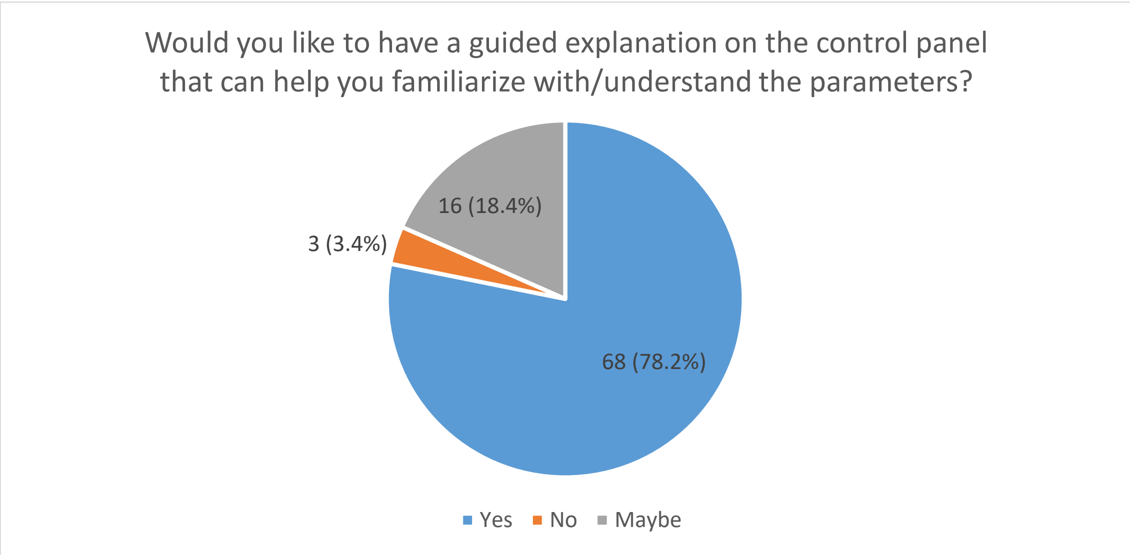


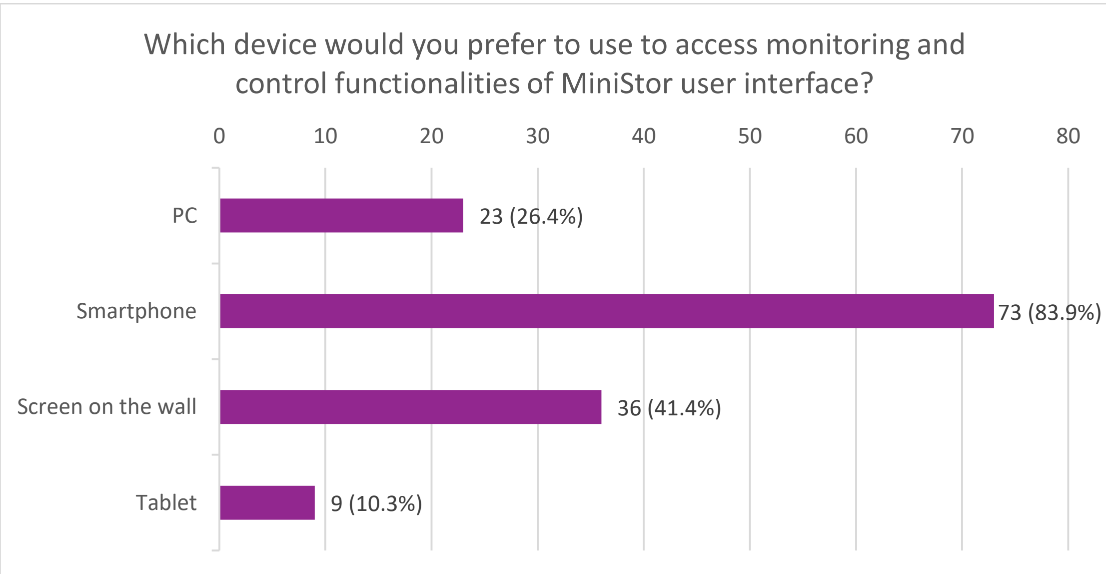
*Option "Other" included various answers: system status, maintenance info, the system should optimize user behaviour



*Option "Other" included various answers: manage a humidifier, manage smart plugs, the system can regulate itself using algorithms, none are relevant to my flat


Would you like to receive demand response (DR) event notifications (price signals) in order to decrease electricity energy costs?
18 (20.7%)
5 (5.7%)
64 (73.6%)
Yes
No
Maybe/Not sure

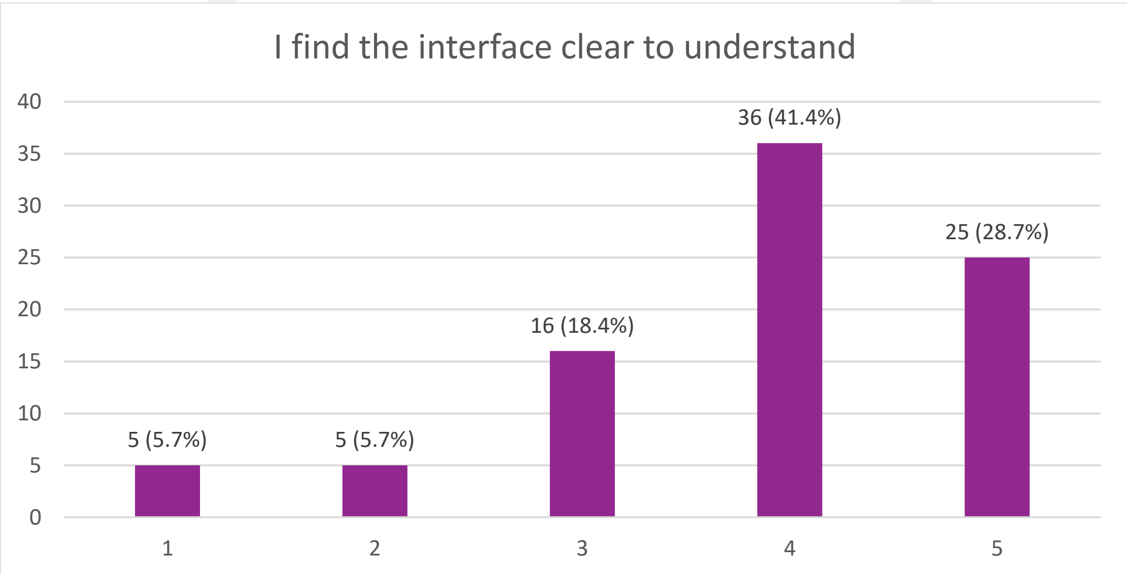

Would you like to have a guided explanation on the control panel that can help you familiarize with/understand the parameters?
16 (18.4%)
3 (3.4%)
68 (78.2%)
Yes
No
Maybe


Which device would you prefer to use to access monitoring and control functionalities of MiniStor user interface?
0
10
20
30
40
50
60
70
80
PC
23 (26.4%)
Smartphone
73 (83.9%)
Screen on the wall
36 (41.4%)
Tablet
9 (10.3%)

7.3 MiniStor Mock-ups

The third group of questions is related to the graphical design of the system through the mock-up screens of the User Interface that were also displayed to the questionnaire, so that respondents can evaluate them. In general, the results show that respondents find the interface easy (41.4%) and very easy (28.7%) to understand. Even though, some of the respondents indicated concerns for the complexity of the UI, especially if the user is not familiar with the subject of energy storage and building management. The interface indeed contains also more advanced information and graphs. The main reason for this, is that during the course of the project the initial MiniStor customers are basically the pilot sites. Pilot sites in the project are represented by organizations with scientific and research activities, thus some of the requested features might not be of interest to residential users but provide useful insights for the project. A simpler version with less information can of course be adapted for the commercial version of MiniStor.

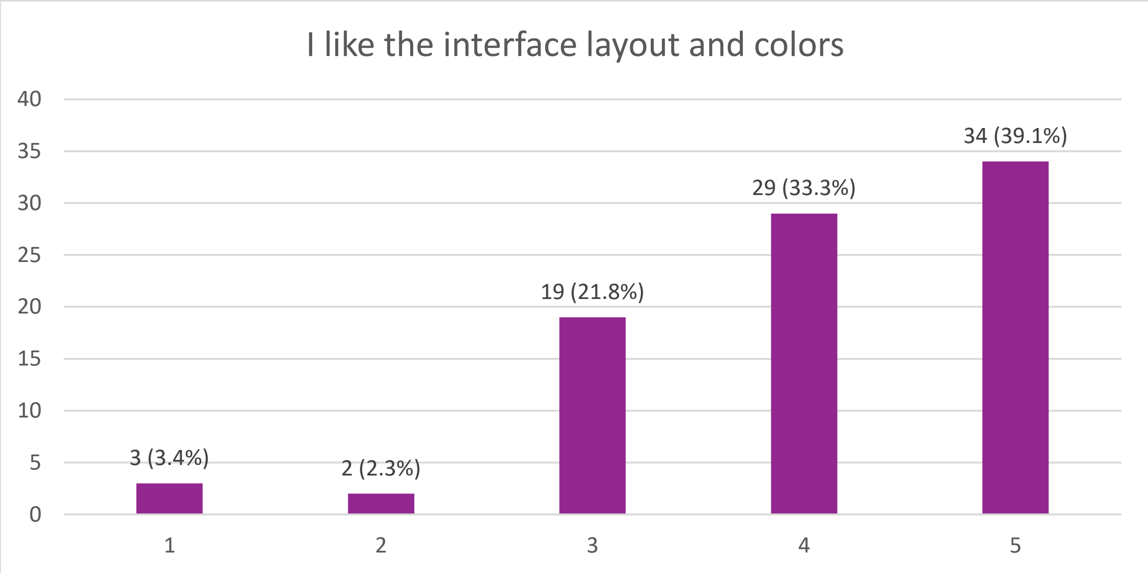
At the same time, more than 70% of the respondents expressed that they prefer the interface layout and colours. Around 60% of them think the texts and buttons are easy to read. For the latter question, we got some comments that the size presented on the mock-ups would be difficult to read for elderly people. Therefore, we will take this into account during implementation. Around 70% of the people consider that the interface sections are well organized which validates our initial grouping of the web site content into specific tabs. For each of the above questions an optional explanation was requested for their answer. This has allowed us to gather valuable feedback on these subjects. Some of the comments include positive feedback e.g. "I like how the 'Microgrid' tab concentrates all information in a single screen." or "Prioritizes essential information with minimal distraction.", while others suggest changes and improvements that will affect the implementation work, such as "Liked the layout, would add some help buttons for more explanations", "I would have a basic mode for everyday use, and an expert mode for drilling down to the details" and many others. The results are displayed below.



The reason that we placed these "Please explain why" questions after each question is exactly to acquire feedback and ideas for improvement of the interface. We have received different categories of answers, meaning answers that show approval of the design such as "It looks detailed but the symbols are clear and it looks well laid out" or "The interface is well-organised and very easy to follow", but also answers that say the opposite such us "It seems too complex for me". This shows that each user evaluates the interface differently according to his/her needs and stated background. Below we present in a summary the suggestions that we got.

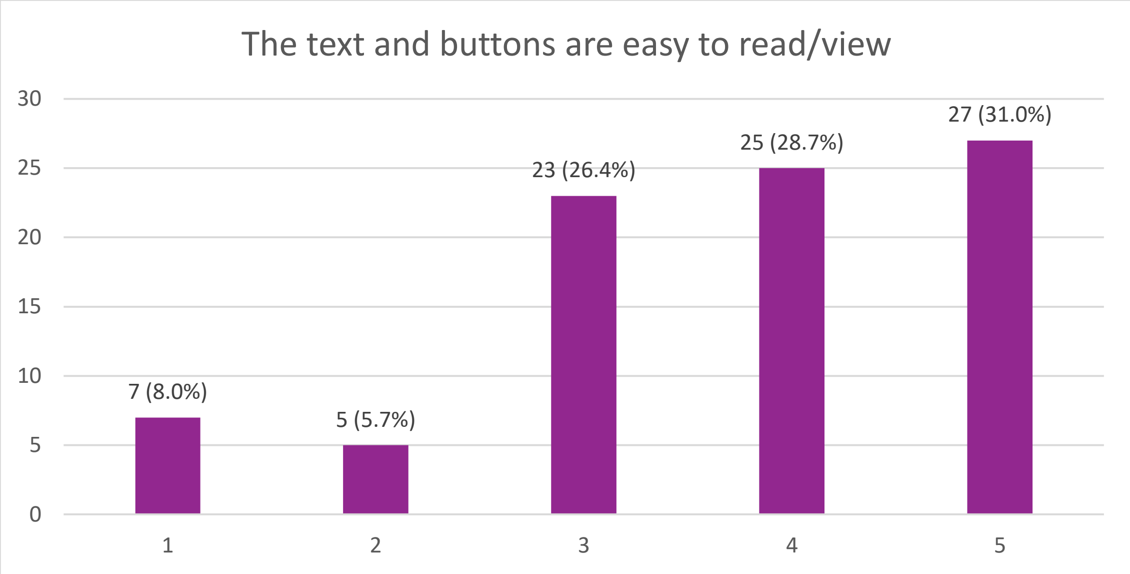
- popup descriptions on mouse hover or similar to describe key terms to the user
- to have the option to see only what matters to me and exclude all the others
- a mini tutorial

- use of public terminology, not professional/engineering
- consistency in colour coding
- a prediction of the cost of energy tomorrow compared with yesterday or last month's average cost

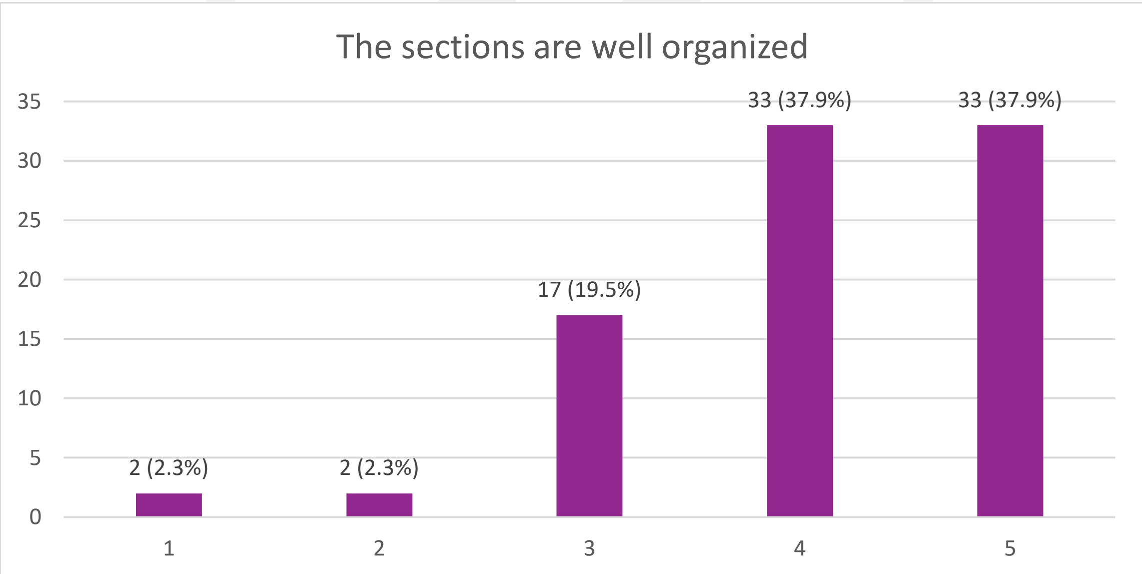


Also in this section we received different answers with most people commenting that they think the colours are appealing, bright and modern, while others commented that they don't matter so much for them. As before a number of people have made suggestions which we have gathered and present as follows:

- Colours should be checked for colour blind people
- In the Control Panel tab - would prefer leaving the background white and turning the colour of any inactive UI controls to a light grey, instead of having "greyed" sections.
- In the plot line figures, you could change the colour palette so when a colour overlaps another the outcome of the blending is not a brownish shadow
- Maybe it would help to have the side panels in a slightly different colour
- In the Control Panel tab - there should be more typographical or graphic differentiation between 'information' (cannot be changed by reader) and 'operable' data (data the user can change and set).



In this question we also received comments that the text would be easy to read for young people but hard to read for older people or from a mobile screen, which we plan to take into account and provide different font sizes for the user to select. A basic issue that we have identified with this question, as also some of the answers mention, is the fact that the mock-ups attached to the survey are probably in a different scale than the one in real life (e.g. the screen of a laptop), which makes it difficult to provide a justified answer, since it mostly depends to the scale shown in the questionnaire and thus explains the responses stating that the text could be bigger.



Almost all responses claimed that the organization of the sections is clear and that they seem in line with processes. The respondents approved the different tabs and claimed there is no mix of the content and that it seems easy to find the required information. On the other hand we also received one comment that the person would need a period of time to understand them or that they might not use all of them, but the general feeling that we grasped from this question is that sections organization is easy on the eye.

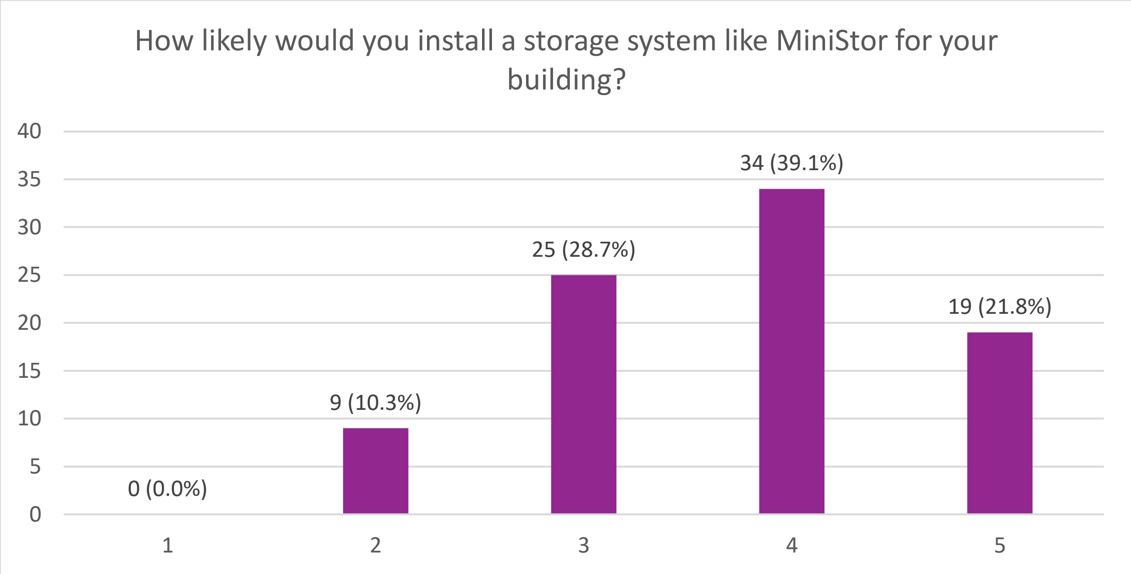
What you liked the most/ the least? What would you change?

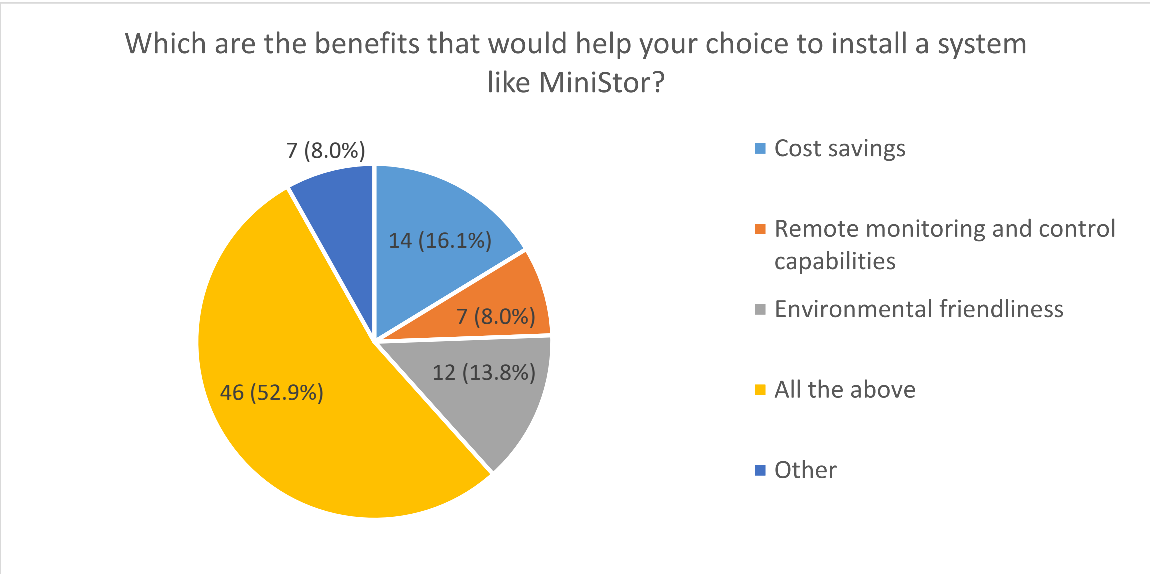
This was the most interesting question for us, since respondents could give us a general feedback on the most important parts for them while also suggest a number of ideas. We have separated the responses in three categories and summarized the responses in each one:

- Most liked features
  - The Microgrid view and how every value and relationship fits on one screen
  - Colours and Graphics.
  - Prioritization of essential information with minimal distraction
  - The organization of sections.
- Least liked features
  - The amount of screens for average user needs to be less
  - The level of detail and information
- Future suggestions
  - Help buttons for more explanations
  - Have a basic mode for everyday use and an expert mode for drilling down to the details. The basic mode should have larger icon/emoji type interface, in primary colours, for at-a-glance use by non-technical users. The example screens above, would be fine for expert mode.
  - Create an alternative view for a smartphone or tablet
  - The analytics may be more interesting when used over a multiday period
  - Green colour can be used to show eco-friendly power generation
  - Break screen into areas with slightly different colours
  - On the main screen should have some bigger number the most important data, e.g. actual loads and the generated energy by the system.
  - Consider modifying panel titles to make them less technical, more user-friendly.
  - Have more graphic design input in control panel tab through which users will most interact
  - There should be an equivalent of a newspaper headline that draws immediate attention to the cost value of the saving the system has achieved today and in the last week, month and year. Perhaps this should be the screen-saver, or at least the first page.
  - Put more information on the graphs
  - The prediction errors of energy consumption forecasting would be intuitive for evaluating model's performance during platform testing, but such an information might be redundant or even confusing for the average end-user after platform release.

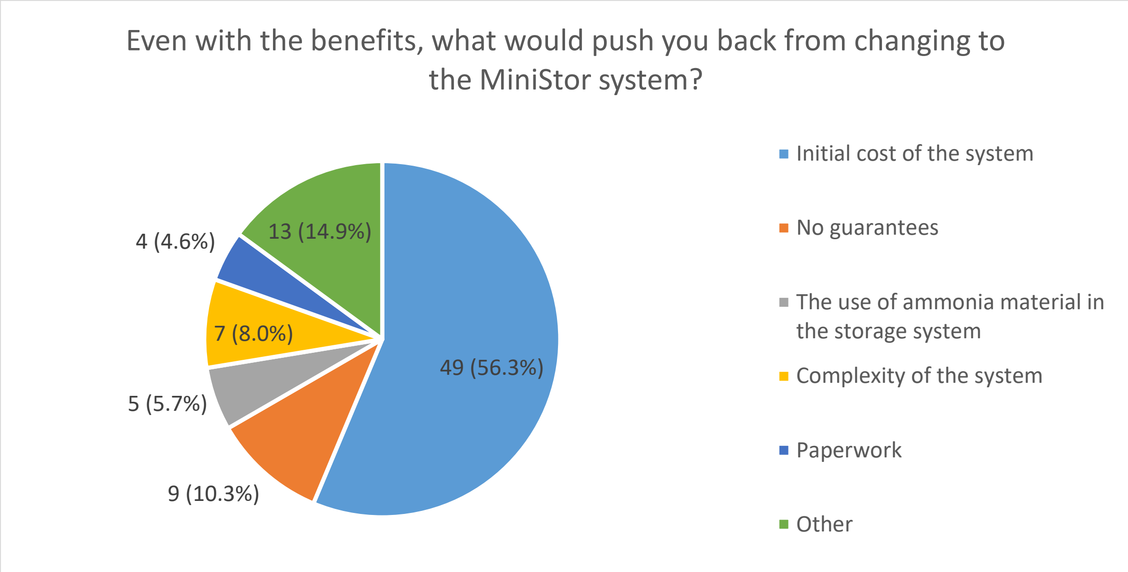
7.4 Business opportunity

With this last group of questions, we have tried to identify the willingness of the respondents to install a storage system such as MiniStor in their building. Answers reveal that they would be interested in installing such a system especially if this brings cost savings, is environmentally friendly and allows for remote monitoring and control of the building parameters, which seem to be MiniStor’s strong assets. However, a high initial cost of the installation would probably push them back from taking this decision. This initial feedback on the business opportunity of the MiniStor solution helps us to identify the market needs and expectations for such a system and since this feedback is taken at an early stage, it gives us the opportunity to focus on the benefits and try to eliminate the barriers.





*Option "Other" included various answers: Resilient sustainability along times, Cost savings and Environment, Clear advice, Capital cost, safety, cost of installation and projected savings.



*Option "Other" included various answers: already have an excellent smart home, initial cost and ammonia safety concerns, not the owner of the house, effort concerning a solar system installation to the house, not enough information to answer this question, need to retrofit my home for high energy efficiency before such an energy-management system would be worthwhile, several of the above - cost, complexity, high pressure salt, time to recover the initial financial investment

8 Conclusions

A first version of the MiniStor User Interface design has been presented in the current deliverable, along with its evaluation by potential representative end-users. Defining the user requirements is of paramount importance for successfully identifying the user interaction with the system and consequently determining the key features that the User Interface must have. In this deliverable, three different techniques: the User Stories, the Use Cases and the interface mock-ups, have been successively applied in order to achieve this objective.

As a first step, five potential types of end-user roles were identified, each one with different interaction capabilities and permission uses. Afterwards, a significant number of User stories was defined. Each story expresses a small unit of work and describes features that the system's interface should have in order to enable the user – system interaction. The user stories were also grouped into larger bodies of work called epics: administration, monitoring, control, prediction, demand response events, alerts / notifications, maintenance and KPIs monitoring. Another way that was used to express user requirements involved making more detailed scenarios of system's use, was the definition of the Use Cases. These scenarios focus primarily on the system's behaviour and involve the utilization of a number of distinct features. The analysis of the User Stories and Use Cases enabled the determination of the User Interface key characteristics that were grouped according to the functionality they offer, into the following categories (tabs): microgrid, data analytics, control panel, prediction and DR events. This enabled the creation of the first designs of the User Interface in the form of mock-ups for each of the aforementioned categories of functionality.

The proposed design of the User Interface was evaluated through a questionnaire that was distributed to potential end-users, while special attention was given to collect answers from people with different background characteristics. The evaluation results revealed the significance of monitoring energy parameters, scheduling electricity demand for reducing costs and the importance of incorporating a guided explanation of the interface control panel. Furthermore, almost 70% of the responders found the proposed interface easy to understand, well organized and were fond of the selected layout and colouring. However, the incorporated text and buttons could be improved in order to enhance their clarity.

In general, the outcome of this first evaluation regarding the user requirements will provide a useful input for T2.1 “Identification of stakeholder requirements, market needs and barriers for implementation” and T2.4 “Characterization of an interoperable and adaptable storage solution, easily integrated with PVT and other local RES”. Useful results can also be incorporated in T3.1 “Initial dimensioning of the whole system according to general use typologies”, T5.1 “Design of the MiniStor control and self-optimization platform (Smart Home energy management system)” and T5.3 “IoT-platform for user interaction with system for operation and performance (visualizations, alerts, actionable devices, user interface)”, especially regarding the information that the User Interface should include. Finally, the results of the end-users' survey concerning the benefits of installing a storage system such as MiniStor in their building, can be further analysed in order to improve the communication with external stakeholders in the framework of WP8.

Annex I

Use case Title	Specify a descriptive title
Description/Goal	A sentence describing what this use case aims to achieve
Primary Actor	Who will perform the related activities
Pre-conditions	Any conditions that should be satisfied before the use case takes place e.g. the user should have a computer with a browser installed
Basic Path/Success Scenario	A flow of activities and expected results
Alternative Paths	Anything that can go wrong at the above flow

Annex II

MiniStor Design Evaluation Form

MiniStor is a compact, integrated system that provides sustainable heating, cooling and electricity storage for new and existing buildings, by using solar-based renewable energy sources. It is a human-centric system that provides a home energy management system, which is connected to IoT sensors and actuators for monitoring and control of different parameters . MiniStor aims to reduce the energy consumption in buildings by at least 44% with a return-on-investment period of 6.7 years.

This questionnaire is intended to the evaluation of the design of MiniStor system - features and functionalities that will be offered to residential end-users.

* Required

Background information

1. What is your age? *

Mark only one oval.

- ◯ 18-45
- ◯ 46-65
- ◯ 65+

2. What is your gender? *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Other: ____________________

3. How many years do you live in your house/apartment/accommodation? *

____

4. Number of occupants of the house *

Mark only one oval.

- 1
- 2
- 3
- 4
- 5
- 6
- 6+

5. Your skills and understanding on energy storage/ building management *

Mark only one oval.

- Poor
- Average
- Good
- Expert

6. Are you fluent in English? *

Mark only one oval.

- Begginer
- Intermediate
- Advanced

7. Have you carried out any energy efficiency improvements to your home? (such as adding insulation, changing your boiler, adding PV panels, or similar) *

Mark only one oval.

( ) Yes *Skip to question 8*

( ) No *Skip to question 9*

8. If yes, please specify what was the improvement and when was this done?

____

____

____

____

____

MiniStor features and functionalities

9. Which are the parameters that you would like to monitor, through the MiniStor User Interface, concerning the house conditions? *

Check all that apply.

- [ ] Electrical Consumption (kWh)
- [ ] Thermal Consumption (kWh)
- [ ] Hot Water consumption (kWh)
- [ ] Room temperature (°C)
- [ ] Room humidity (%)
- [ ] Status of electrical appliances
- [ ] Consumption of electrical appliances (kW)
- [ ] Outdoor conditions (temperature, humidity, wind, solar radiation)
- [ ] All the above

Other: [ ] ____________________

10. Which are the parameters that you would like to monitor, through the MiniStor User Interface, concerning the MiniStor system conditions? *

Check all that apply.

- [ ] State of charge for electrical storage (%)
- [ ] State of charge for thermal storage (%)
- [ ] Current Status of the system (Charging/Discharging)
- [ ] Daily energy balance (kWh)
- [ ] Electricity production from Photovoltaic-Thermal panels (PVT) (kWh)
- [ ] Thermal production from Photovoltaic-Thermal panels (PVT) (kWh)
- [ ] System Marginal Price for electricity (€/kWh)
- [ ] Daily Energy Costs (€)
- [ ] All the above

Other: [ ] ______________________

11. Which are the parameters you would like to control through the MiniStor User Interface? *

Check all that apply.

- [ ] Set the heating/cooling temperature of the thermostat
- [ ] Set heating/cooling schedule for the next day/week
- [ ] Select between automatic and manual modes for heating/cooling
- [ ] Respond on electricity price signals/demand response (DR) events (accept/decline)
- [ ] All the above

Other: [ ] ______________________

12. Would you like to receive demand response (DR) event notifications (price signals) in order to decrease electricity energy costs? *

Mark only one oval.

( ) Yes

( ) No

( ) Maybe/Not sure

13. Would you like to have a guided explanation on the control panel that can help you familiarize with/understand the parameters? *

Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) Maybe

14. Which device would you prefer to use to access monitoring and control functionalities of MiniStor user interface? *

Check all that apply.

- [ ] PC
- [ ] Smartphone
- [ ] Tablet
- [ ] Screen on the wall

MiniStor Mockups

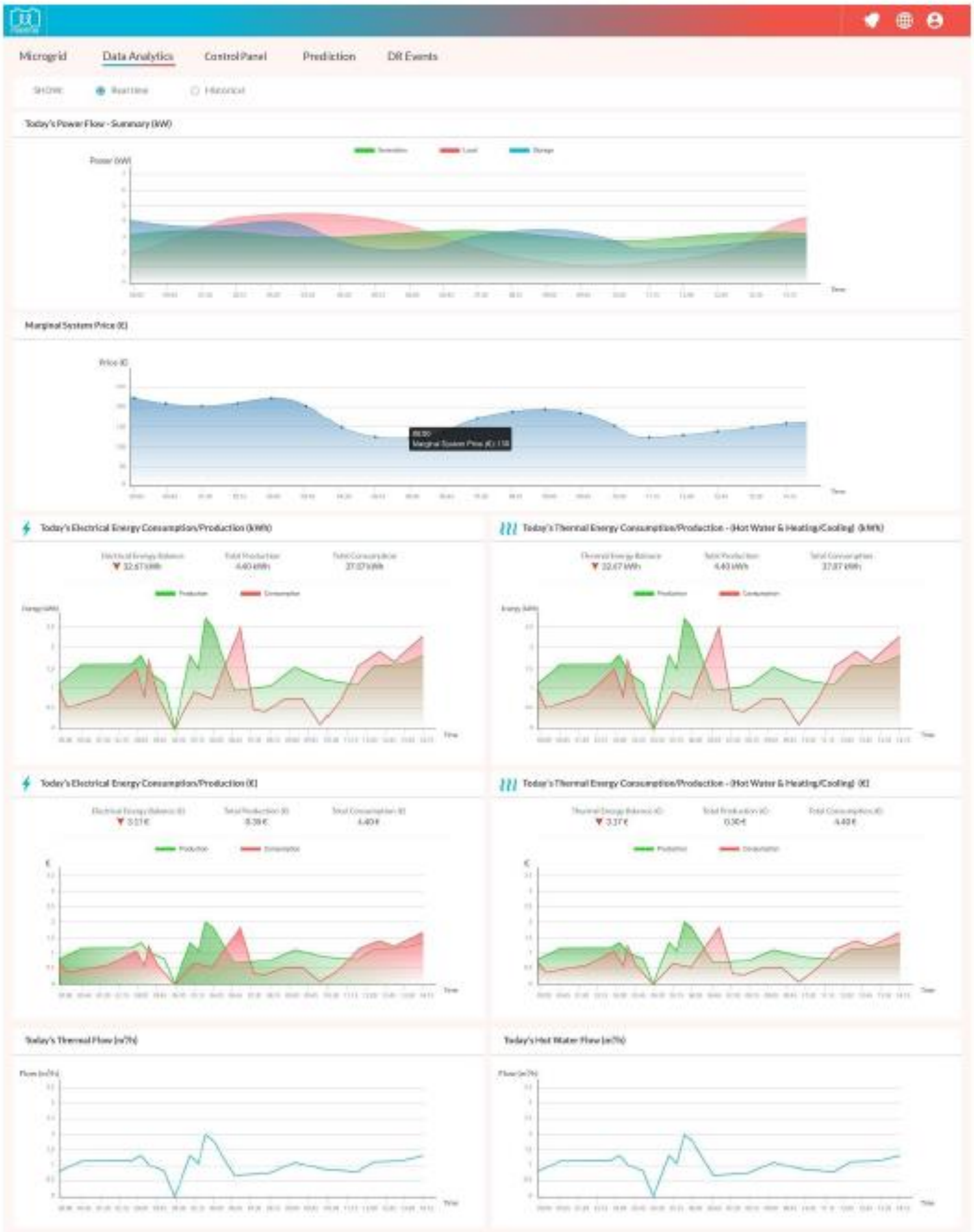
In case images are not clear enough you can either zoom in (Ctrl+) or access the link https://drive.google.com/drive/folders/1eJ_RmmqsZDuVzkXYRN9BsEx0C1q-lbyb?usp=sharing

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

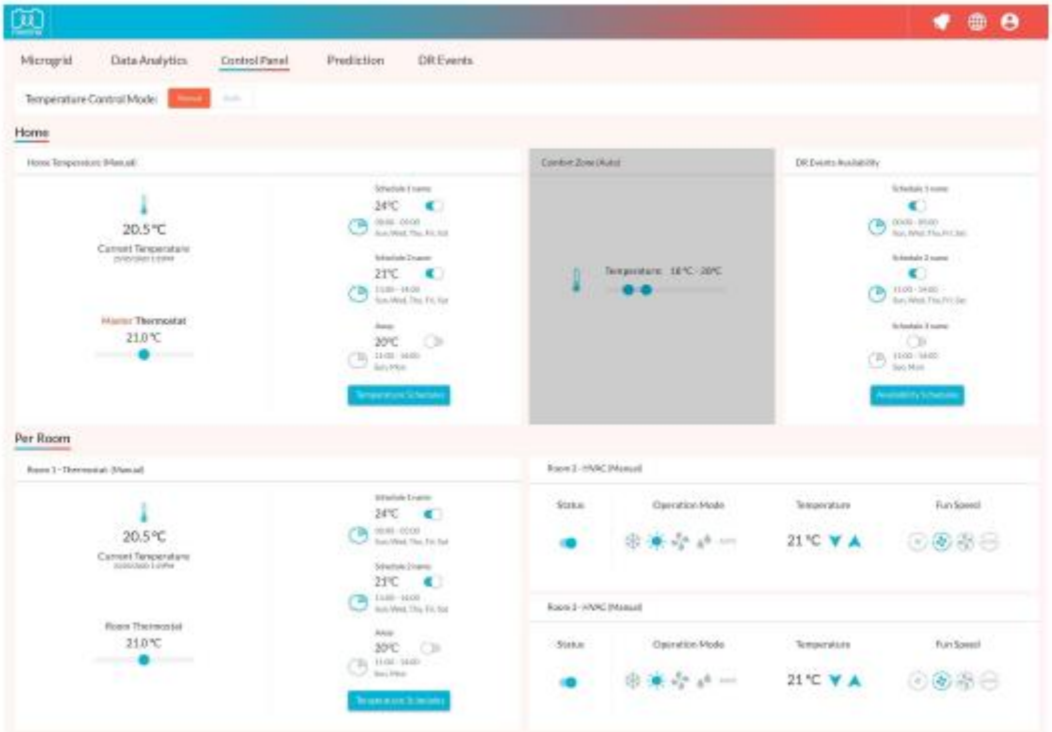
Home Screen (case: exporting electricity to grid, importing natural gas, storage discharging)

Home screen (case: importing electricity from grid, thermal storage discharging, electricity storage charging)

Data Analytics



Control Panel Manual Mode



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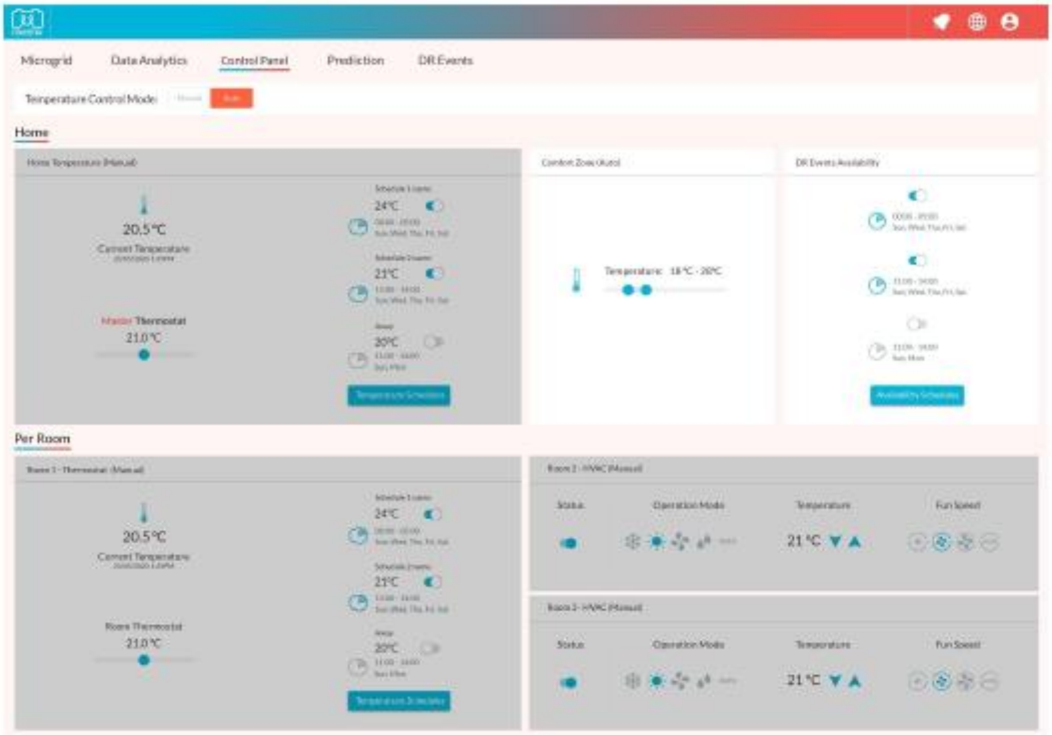
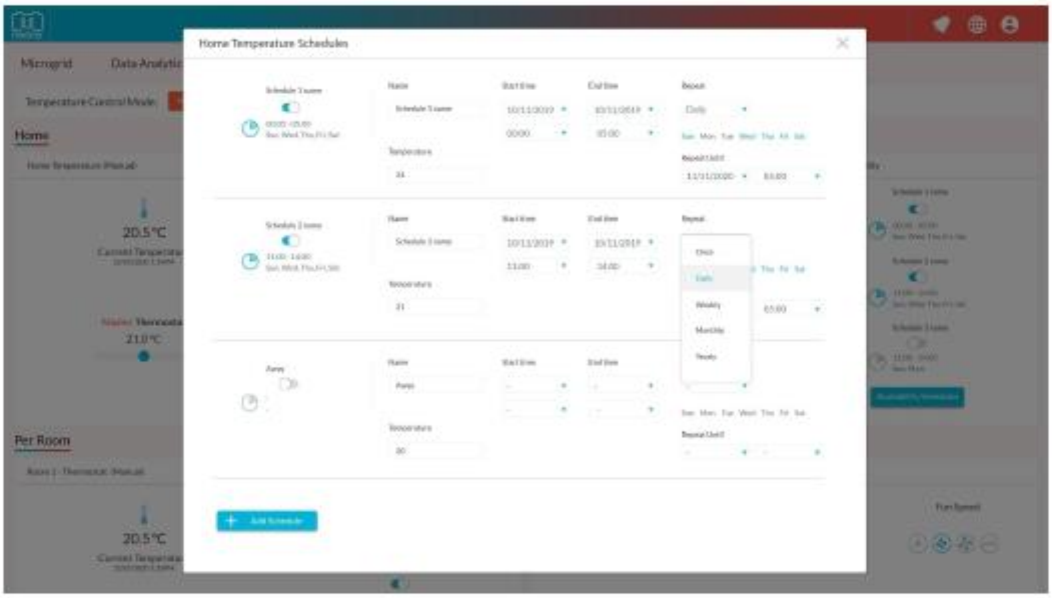
Control Panel Auto Mode



Control Panel Scheduling

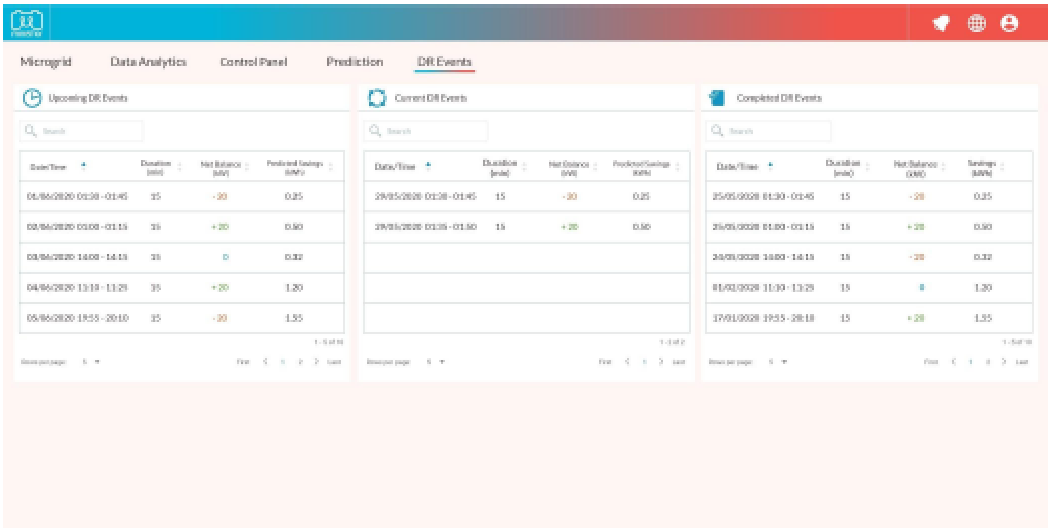


Energy prediction one-day-ahead

Energy prediction vs actual today (hide prediction error)

Energy prediction vs actual today (show prediction error)

Demand Response (DR) events



15. I find the interface clear to understand *

Mark only one oval.

	1	2	3	4	5	
disagree	◯	◯	◯	◯	◯	agree

16. Please explain why

17. I like the interface layout and colors *

Mark only one oval.

	1	2	3	4	5	
disagree	◯	◯	◯	◯	◯	agree

18. Please explain why

19. The text and buttons are easy to read/view *

Mark only one oval.

	1	2	3	4	5	
hard to read	◯	◯	◯	◯	◯	easy to read

20. Please explain why

____

____

____

____

____

21. The sections are well organized *

Mark only one oval.

	1	2	3	4	5	
disagree	◯	◯	◯	◯	◯	agree

22. Please explain why

____

____

____

____

____

23. What you liked the most/ the least? What would you change?

Business opportunity

24. How likely would you install a storage system like MiniStor for your building? *

Mark only one oval.

1	2	3	4	5
⬭	⬭	⬭	⬭	⬭

25. Which are the benefits that would help your choice to install a system like MiniStor?

Mark only one oval.

- Cost savings
- Environmental friendliness
- Remote monitoring and control capabilities
- All the above
- Other: ______

26. Even with the benefits, what would push you back from changing to the MiniStor system?

Mark only one oval.

- No guarantees
- Paperwork
- Initial cost of the system
- Complexity of the system
- The use of ammonia material in the storage system
- Other: ____________________

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