WP7 Pilots Deployment, Operation and Socioeconomic Evaluation

Document Version: **1.0**

D7.3 Intermediate Pilots Deployment, Operation and Validation

Project Number:	Project Acronym:	Project Title:
893079	PHOENIX	Adapt-&-Play Holistic cOst-Effective and user-frieNdly Innovations with high replicability to upgrade smartness of eXisting buildings with legacy equipment

Contractual Delivery Date:	Actual Delivery Date:	Deliverable Type* - Security**:
31/10/2022	02/11/2022	D - PU

* Type: P - Prototype, R - Report, D - Demonstrator, O - Other

** Security Class: PU- Public, PP - Restricted to other programme participants (including the Commission), RE - Restricted to a group defined by the consortium (including the Commission), CO - Confidential, only for members of the consortium (including the Commission)

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Abstract:

This document presents the intermediate development of all pilots including their integration into the PHOENIX platform, their validation in relation to the operation of the PHOENIX innovations developed in WP3 and WP4 and WP5 and provides an update on trial executed and progress against KPIs. The plan for future trial execution and completion is also detailed.

Keywords:

Legacy equipment, Building's upgrade, Integration, Demo-sites, Smartness.

Revision History

The following table describes the main changes in the document since created.

Revision	Date	Description	Author (Organization)
0.1	23/06/2022	Preparation of the skeleton of the document	Fergal (Arden)
0.2	28/07/2022	Description of the Irish Pilot Trials	Eoin (Arden)
0.3	01/08/2022	Description of Comfort Services	Kostas (Suite5)
0.4	14/10/2022	MIW Pilot description and trials	Pablo (MIW)
0.5	14/10/2022	Swedish Pilot description and trials	(LTU)
0.6	16/10/2022	Greek Pilot description and trials	Maria (KAMA)
0.7	17/10/2022	UMU Pilot description and trials	Juan (UMU)
0.8	18/10/2022	Integration and editing	Eoin (Arden)
0.9	19/10/2022	SRI assessment description	Juan (UMU)
0.10	24/10/2022	Integration and editing	Fergal (Arden)
0.11	25/10/2022	Summary and Conclusions	Fergal (Arden)
0.12	27/10/2022	Final Inputs Integration	Fergal (Arden)
1.0	31/10/2022	Final Deliverable for Submission	Fergal (Arden)

Executive Summary

This deliverable is part of WP7 "Pilots Deployment, Operation and Socioeconomic Evaluation". It is the third in a set of deliverables that describes the development, operation and validation of pilots in the PHOENIX project.

The deliverable updates progress on the use case trials defined for each pilot in D7.2 and describes progress on the specific Key Performance Indicators (KPIs) that have been defined in previous related deliverables and are being monitored throughout PHOENIX trials in order to validate these use cases. The progress, results and data for the specific defined trials are presented for each pilot together with a description of deployment of services developed in WP3 and WP4 of the PHOENIX project.

Data for each trial progressed or completed is presented and analysed with respect to the KPIs defined for each trial. There is a description of trials executed as well as future plans for trials. The results of trials are analysed and KPIs quantified where relevant and possible.

Where trials have not been completed due to factors including complications in integration or seasonality of energy demands these complications are described and the plans for the execution of trials are laid out. The next steps for pilot development and operation are presented.

The impact of the measures implemented through integration with the PHOENIX platform on the smart readiness indicator for each pilot is assessed and the impact of measures is analysed by domain and service group to identify the most effective measures for SRI improvement.

Finally, conclusions are reached and next steps are defined.

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 893079, but this document only reflects the consortium's view. The European Commission is not responsible for any use that may be made of the information it contains.

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Abbreviations

BMS	Building Management system
CB	Context Broker
CDD	Cooling Degree Day
D.	Deliverable
DAM	Day Ahead Market
DER	Distributed Energy Sources
DoA	Document of Actions
DHW	Domestic Hot Water
DRE	Demand Response Events
HDD	Heating Degree Day
HVAC	Heating, Ventilation, and Air Conditioning
KPIs	Key Performance Indicators
PoC	Proof of Concept
PV	Photovoltaic
SOC	State of Charge - the amount of energy currently stored in the battery (%).
SRI	Smart Readiness Indicator
ST	Solar Thermal
UC	Use Case
WP	Work Package

1. Introduction

1.1. Scope of the Document

The main objective of Deliverable 7.3 is to document the intermediate development of the pilot sites in terms of installation, trial plans and validation of PHOENIX services. There are five pilot sites involved with the PHOENIX project spread across four European countries (Ireland, Spain, Greece and Sweden). Legacy equipment at the pilot sites has been integrated with the PHOENIX platform to deliver services to improve smart readiness, efficiency, comfort, convenience, sustainability and grid flexibility. This document provides an update on progress in delivering these services and reports on the assessment of improvements and metrics employed.

1.2. Relevance to other deliverables

This deliverable builds on and updates previous WP7 deliverables D7.1 and D7.2. In particular it updates progress and future plans for pilots based on the pilot plan and KPI map set out and defined in D7.2. D7.4, the Final Pilots Operation and Validation report will update this document and provide the conclusive report on pilot trials. The set of three deliverables that describe the upgrades and integration of legacy equipment implemented as part of the PHOENIX project, namely Deliverables 3.1, 3.2 and 3.3 describe upgrades to legacy equipment implemented to enable the deployment of services and execution of trials.

WP4 Deliverables 4.1, 4.2 and 4.3 describe the implementation of the Smartness Hub in the PHOENIX platform and pilots. D5.2 describes services for building occupants and D6.2 describes services for energy utilities and the grid.

1.3. Structure of the document

This document comprises five Sections including the introduction. Section 2 describes the evaluation methodology employed to monitor performance at the pilot sites categorised as Energy Performance, Load Shifting and Smart Bills and Comfort and Convenience. Section 3 describes the pilot trials progress and future plans and reports on KPIs demonstrated and achieved. Section 4 describes the impact of measures at the pilots on the smart readiness indicator (SRI) and the automatic evaluation methodology developed. Finally, Section 5 documents conclusions and next steps.

2. Evaluation Methodology

2.1. Energy Performance

The first step to determine the improvement of energy performance, following the implementation of PHOENIX services, began when the project was launched with the collection of historical data. This data is used to calculate the energy baseline of each pilot. First a 'normal' year of consumption was chosen. This omitted the inclusion of consumption during COVID lockdowns as consumption was far from normal during these periods. In order to evaluate the improvement in energy performance of the heating systems at each pilot, it was determined that calculating the baseline energy consumption for heating and cooling at each site would be the best way of doing so. The idea of the baseline calculation is to provide a control which allows one to determine efficiency and performance gains following the implementation of PHOENIX services. In order to calculate the baseline, heating degree data as well as consumption data was collected. Consumption for 2019 was broken down into weekly consumption and a scatter chart was produced using consumption and heating degree data as seen in Figure 1.

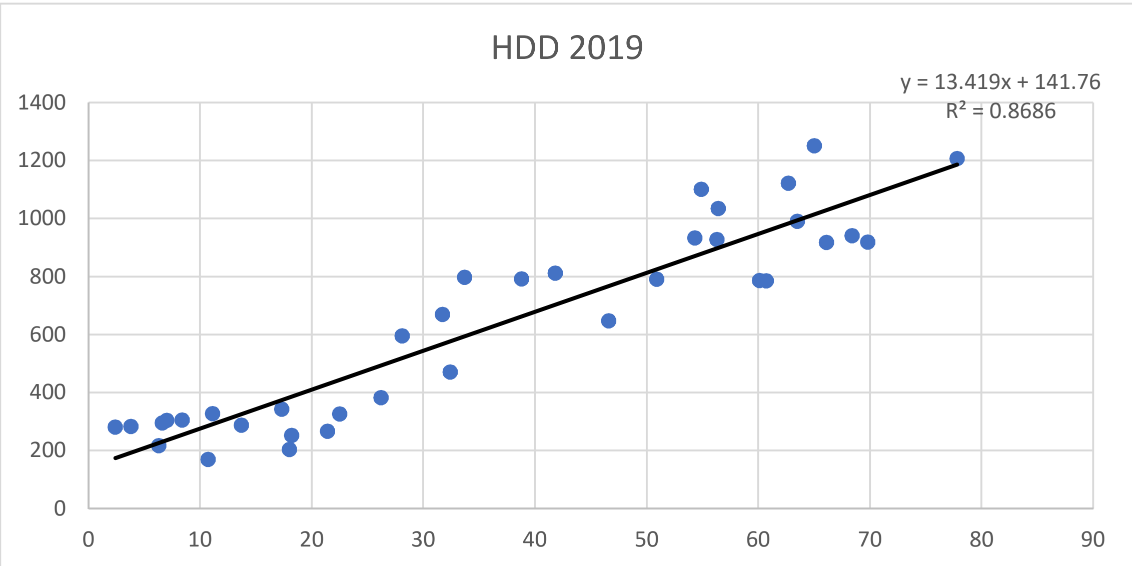


Figure 1 Scatter Plot of Weekly HDD and Gas Consumption

The line formula produced from the plot enables consumption to be predicted and actual consumption to be benchmarked against it as shown in Figure 2.

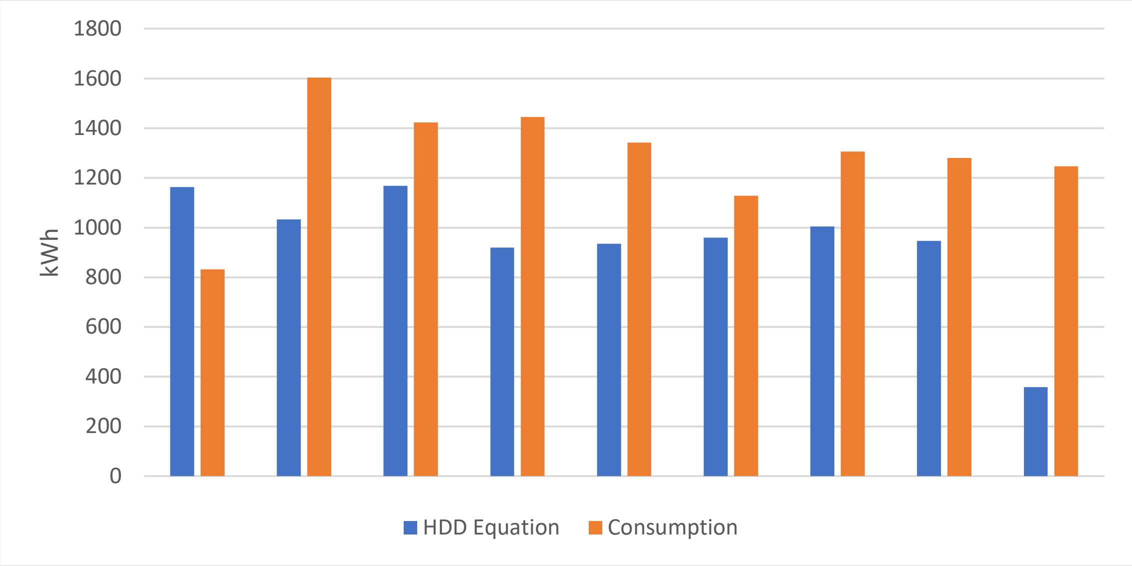


Figure 2 HDD vs Consumption

On the other part, the evaluation of the energy performance of the pilot buildings is based on a thermal coefficient. Each pilot has been asked to indicate a measuring device representative of their overall consumption. In the case of those buildings that do not have such a global device representative of all the building, but rather individual consumptions of each room, the energy performance is carried out individually (with the possibility of giving a global energy performance, based on all the rooms, by aggregating them).

Once those devices are identified and provided, the energy performance is calculated with some other parameters such as the difference in temperature with the building outside and inside and the floor room. At the end the evaluation of energy performance of the building with their real data consumption is obtained.

It should be noted that also mechanism to quantify the effectiveness of the different services have been put in place. This will allow the realisation of bottom up measuring of the effect that the different services may have on the overall energy use of the buildings.

2.2. Load Shifting and Smart Bills

The Clean Energy Package and associated initiatives in smart buildings and smart grids will transform how electricity consumption is measured, managed, and paid for by providing customers with more insight than they currently have. New smart meter technology will provide consumers with information that will lead to more accurate billing by suppliers and better and more accessible information for customers about their energy use, which they can use to make better choices about their electricity consumption. The more accurate information provided by smart meters will also help electricity suppliers to create new smart services and products, such as Smart Time-of-Use tariffs and Smart Pay-As-You-Go tariffs.

In order to evaluate the effectiveness of load shifting, two methods are employed. Firstly, the metered consumption of a device during a period where a direct intervention by the PHOENIX platform actuates a load on or off can be considered a load shifted provided that the intervention and actuation merely shifts a load and does not affect overall consumption. This method is useful for evaluating load shifted for the PHOENIX project and potentially in evaluating benefits for demand response market-based incentives in the future.

The second method is aligned to emerging trends and innovation in smart metering and smart billing in the electricity sector. Legacy electricity meters that haven't been replaced by smart meters are only read four to six times per year and the consumption profile has to be estimated for hourly or half hourly time periods so that the consumption can be aggregated by suppliers and bought on the wholesale markets. Therefore, a 'profile' is created for categories of customers. Sites with smart meters have half hourly consumption data available which allows for the introduction of financial incentives to shift load from periods of high pricing to periods of lower pricing (assuming that pricing is a reasonable proxy for overall costs and environmental impacts). A methodology is then needed to evaluate the extent of load shifting. One method, suggested by The Commission for Regulation of Utilities in Ireland1, is to use the standard load profiles for non-smart meters as a baseline and then to compare the actual load profile and to generate a weighted average cost based on the hourly day ahead market (DAM) pricing.

Figure 3 shows the standard load profile for a domestic consumer in Ireland together with the average hourly DAM price. Peak evening consumption coincides with peak pricing indicating an opportunity to save costs through shifting load. There is also a broader need to reduce loads at peak times to facilitate greater use of renewable energy sources and to improve the security and sustainability of electricity supply.

[1] Comparison tools for Time of Use Tariffs, Commission for Regulation of Utilities, September 2020

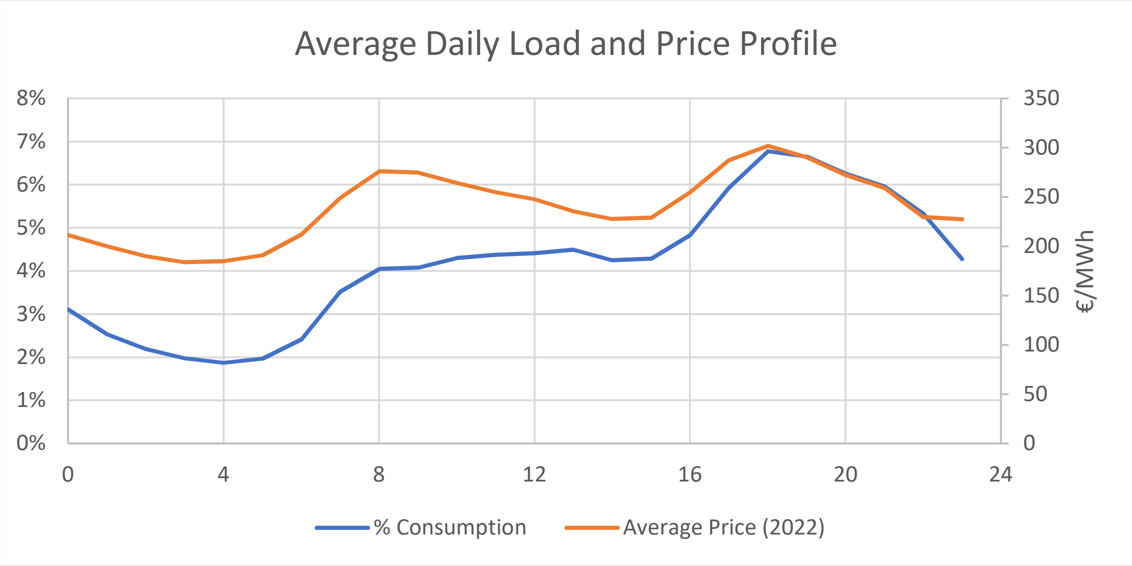


Figure 3 – Standard Load and Price Profile (Ireland)[2]

The presentation of this information will help consumers to evaluate the benefit of smart bills. A further refinement on smart billing which will test the impact of customized tariffs on load shifting and UMU's contribution about smart billing will be the definition and design of a smart tariff based on user behaviour that will be implemented through positive reinforcement. This consists of, after evaluating the user's consumption, periods in which it increases and in which it decreases compared to general demand.

An analysis of behaviour is carried out in relation to day-ahead market prices differentiating between periods of high and low prices. In such a way, that prices will be modified in the periods where this behaviour is considered positive (taking into account high pricing periods), in order to reinforce that it remains so or to encourage it to improve, favouring the reduction of behaviour considered as negative (in terms of price and consumption), all of this focusing on periods where the price is high. For that verification of the behaviour on the design of smart tariffs the solution has included the necessary connections. In this respect, the system can learn about several aspects of the consumption to make sure that the most relevant information is available when designing tariffs. A diagrammatic view of this conceptual connection can be seen on Figure 4.

[2] Sources www.semopx.com & https://rmdservice.com/standard-load-profiles/

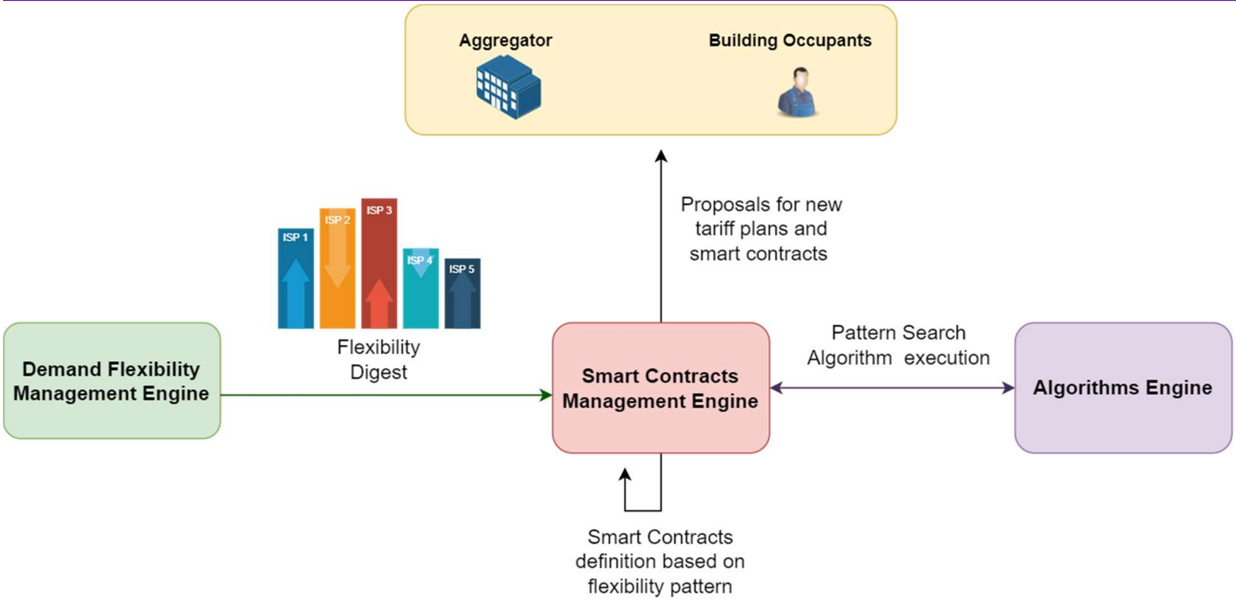


Figure 4 Smart Contracts design flow.

2.3. Comfort and Convenience

Considering the Comfort and Convenience service, as defined in WP5 (and the beta version reported in D5.3), the deployment of the service was performed at the different demo sites taking into account the definition of the demonstration scenarios. More specifically, the distinction among the provision of recommendations or implementation of control actions (via automation) was considered taking into account the capabilities of the different demo areas. On the other hand, the priority per demo site is considered; there are demo areas where the focus is at the provision of comfort services while on others, the focus is on the establishment of a healthy environment (in case IAQ measurements are available).

As part of the demo deployment (and in line with the different integration activities as performed in WP5 and described in D5.3), the following activities were performed:

- Periodical data retrieval (environmental conditions, operational characteristics) from the sensors /devices different demo sites of the project (per building zone).
- Occupancy/Comfort Profiling data retrieval for each building zone of the demo set up.
- Operational settings for the different building zones of the project.

The outcome of this engine as tested during the demonstration deployment is:

- Recommendations about comfort/health as made available through the dashboard.

- Automation control over HVAC systems (controllable devices in the project) as well as some statistics over the control actions performed.

Moreover, a rating process applies over the recommendations triggered; information further processed for fine-tuning the granularity of the messages triggered.

We have to point out that a non-exhaustive number of messages has been triggered to the > 30 building zones configured at the different demo sites. As the demonstration activities evolve, we will evaluate the functional impact of the Comfort and Convenience service at the different KPIs defined in the project.

2.3.1. Commercial Pilots Evaluation

Most pilots have temperature sensors in place that offer the possibility of measuring comfort at a quantitative objective level, but as comfort is a subjective perception of the individual, the predominant method to measure comfort and convenience will be via surveys. Due to the difference in pilot sites in terms of there being a mixture of domestic and commercial sites, there is a necessity for different methods of disseminating the surveys. For commercial pilots, it was decided that a QR code would be developed which would lead directly to a survey. The QR codes would be hung up around the commercial site and enable different occupants to partake in the survey. We decided this would be the most effective method as mass emails are easily ignored. The survey will contain broad questions related to the comfort of the site. Questions concentrated on the convenience of newly inputted PHOENIX services will be directed more towards building managers. This will be specified in the survey.

2.3.2. Domestic Pilots Evaluation

The comfort and convenience of the domestic sites will also be measured via survey, although again most pilots have temperature sensors in place that offer the possibility of measuring comfort at a quantitative objective level. Occupants will be contacted via email to inform them of the purpose of the survey. The survey will be similar to the commercial one with some adjustments to suit the PHOENIX services for the domestic sites that differ from the commercial.

The SRI tool will be a common methodology to measure the improvements on smart services related to comfort and wellbeing/convenience of both commercial pilots and domestic. Calculations have already been carried out using the SRI tool prior to the PHOENIX services and majority of devices being implemented. These calculations will act as a baseline for comfort and wellbeing/convenience to be measured against.

2.4. User Acceptance

Apart from several surveys that have been designed for specific purposes, user acceptance of the PHOENIX services will also be possible to be measured via analysis of the PHOENIX website data. Once the website is launched, pilot leaders will be able to study when occupants utilise services and track changes in consumption as well as how often they log onto the platform. It will also make obvious when Demand Response services are overridden. Overall acceptance won't be able to be fully measured until after occupant training and a few months of the website being functional.

Data will be collected regarding regularity of user login and user interaction. Data around the recurrence of website login can give great insight to user acceptance and so could do the time they spend at different services of the dashboard. It will portray if the ability of the PHOENIX services has been successfully relayed to users and the impact user training has had.

Similarly to how comfort and convenience is planned to be measured, surveys will be disseminated to each pilot. Rather than inundating occupants with surveys, one that combines comfort and convenience as well as user acceptance would be more efficient. The surveys will question occupants on how intuitive they find the PHOENIX platform and the services implemented via PHOENIX.

3. Pilot Trials

3.1. Spanish Pilot (UMU)

UMU has verified that the flexibility platform works well as it has been seen to be effective on the trials, being those DR strategy for flexibility extraction based on both cases: tariffs scheme and renewable generation, and DR strategy for energy saving trial.

Trials of DR events (DRE) with tariffs scheme and renewable generation where the strategy is to shift loads, there is a precooling phase, which consist of decreasing the set point temperature to assure the comfort of the occupants' building during DREs. The results of the three first trials will be further discussed throughout the description of the trials.

Occupants' feedback trials have been performed from the beginning of the heating season and will continue for the cooling season. While ventilation control and crowdsensing trials are designed to be launched in the following months (winter).

DR strategy for flexibility extraction (tariff and renewable scheme) is associated with the load and demand shifting (LoS) with DR strategy for energy savings will be addressed on energy savings target (TES). This last KPI, User acceptance (UA) and people through training and awareness and smart services for users (PRt) are focused on the trial Occupants' feedback and Crowdsensing trials. For the last trial, Ventilation control is associated with the SRI (IsoB) and people through training and awareness and smart services for users (PRt).

3.1.1. Demand Response strategy – Tariffs scheme

This trial was performed in the summer season, more precisely in M22 and M23. Other DREs will be held in the winter season following the same method as described for the previous events.

The time interval in which the event can be carried out is indicated. This does not include non-working hours. Once it has been defined, to analyse within that period, the rises and falls of the energy price, forecasting is carried out by evaluating it. The next day's prices are obtained from the Day Ahead market data collected by PHOENIX server, which publishes, at a certain time of the current day, the real prices of the next day.

Thus, when both occur at the same time (range in which the DRE and the analysis of the decreases in these prices can be carried out), the monitored devices are programmed so that their consumption is transferred to all these periods or simply to the one(s) chosen from them. In this way, a DRE from high price periods to low price periods is obtained. The precooling phase was programmed to set in low tariffs periods and to finish when the high tariff periods come.

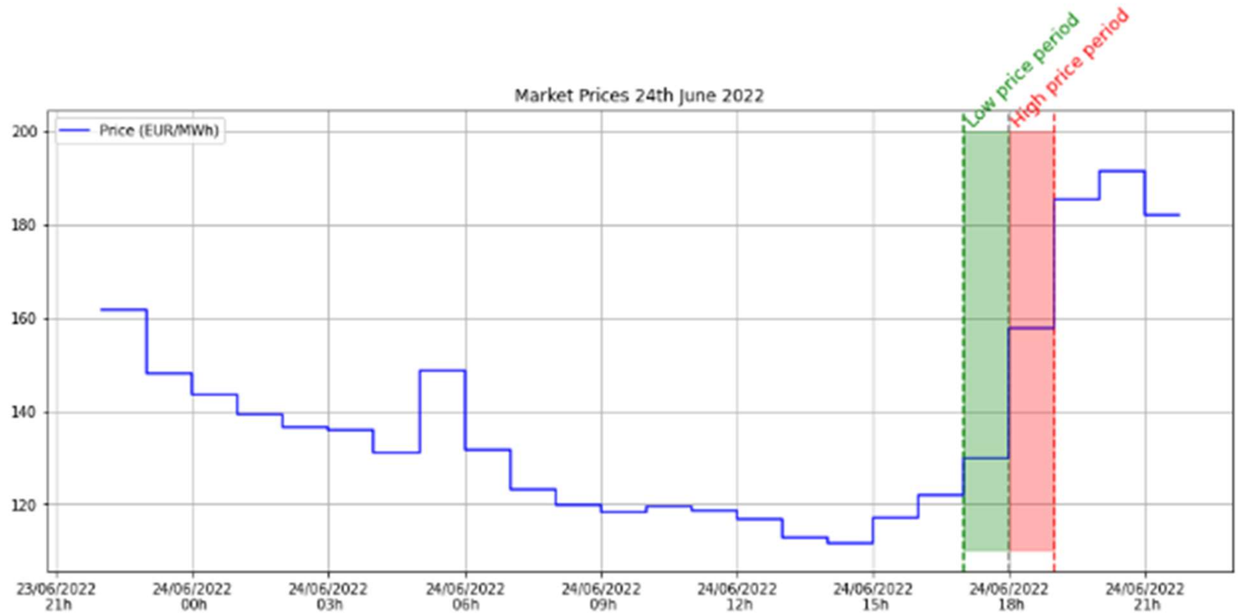


Figure 5 Day Ahead Market Prices for DR Trial[3]

To define the period for this trial, the load shifting was done from high tariff to low tariffs as seen in Figure 5. In high pricing periods (red bar), the HVAC systems will be disconnected and the precooling phase will be executed during the low pricing periods (green bar).

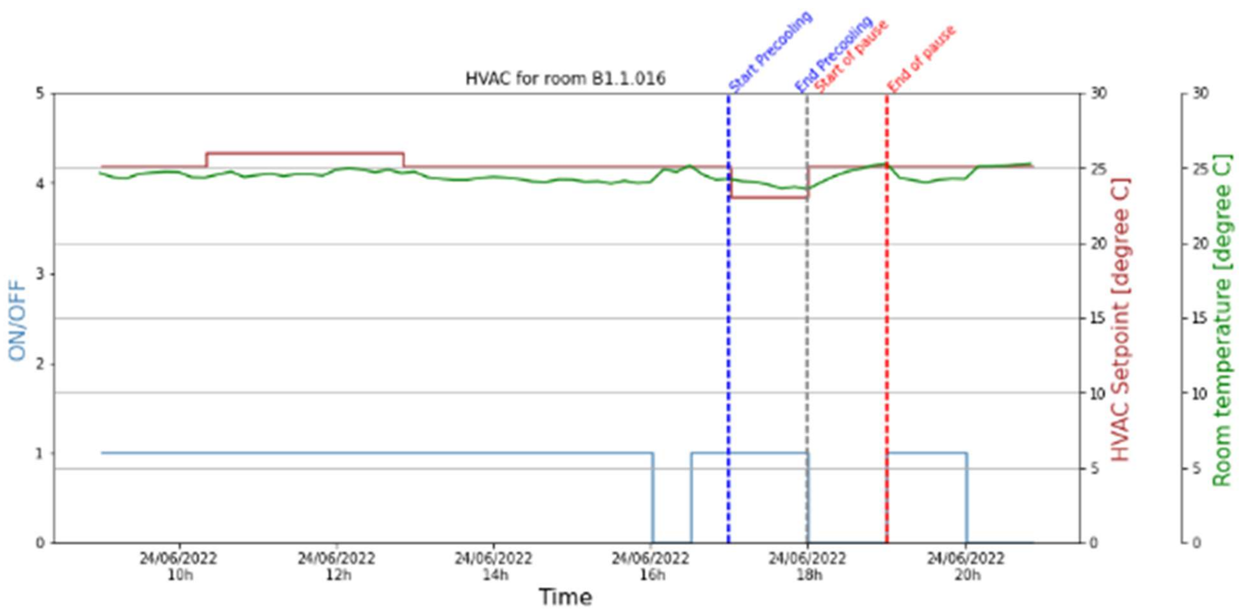


Figure 6 Setpoints and Room Temperature (room B1.1.016) for DR Trial

[3] Sources www.semopx.com & https://rmdservice.com/standard-load-profiles/

By decreasing the setpoint of the HVACs, the precooling phase has started ('start of precooling') when the period previously defined as low the price period begun. Therefore, the temperature of the room was being lowered (green line period in precooling phase) to assure that the thermal comfort is not disrupted during deactivation of the HVACs (DRE). During the shutdown of the HVACs, the room temperature gradually increased until the end of that shutdown to recover the normal condition of the room.

3.1.2. Demand Response strategy – Renewable generation scheme

This trial was performed in the summer season, same as in the trial above. In the winter season there will be more DREs executed following the same method which is similar with the DRE based on tariffs scheme. The main difference is that the high and low tariffs are substituted by high and low renewable generation.

The renewable generation will be represented by calculating CO_2 emissions, so that events will be carried out where emissions go from high to low (low and high renewable energy generation, respectively). CO_2 emissions (gCO_2) were calculated considering the carbon footprint (gCO_2/kWh) and their energy production in Spain (kWh). Once these emissions have been calculated, the time range in which the DRE could take place (work daily hours) was defined. The next step was to identify when there are low CO_2 emission periods followed by high ones to finally perform DRE with load shifting. The precooling phase was programmed to take place in high CO_2 emissions periods and to finish in periods with lower emissions.

As it happened in trial No.1, the period when the DRE was going to take place was defined. In this case the precooling phase will take place during low carbon emission periods that were previously calculated and the shutdowns of the HVACs will be executed during the high carbon emission periods, meaning that the DRE was from the low period of renewable generation to the high one.

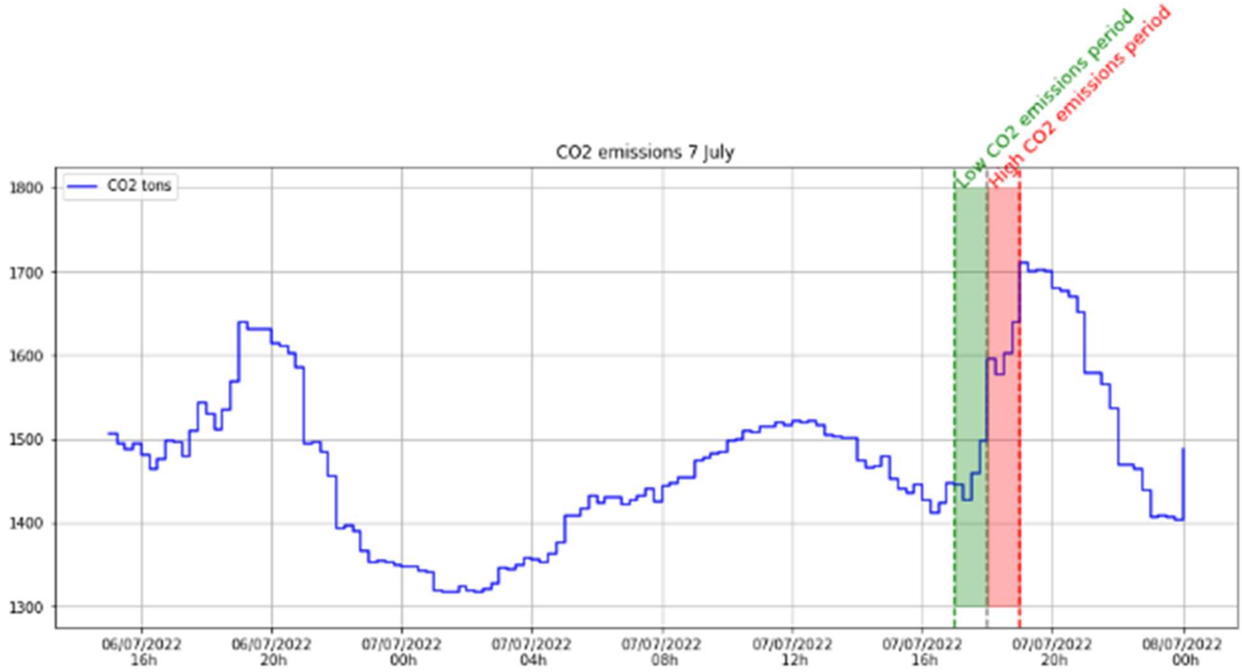


Figure 7 – CO_2 emissions for DR Trial

When the low carbon emission period started, the precooling also began. This means that the setpoint of HVACs the temperature of the room was decreased for maintaining the thermal comfort of the occupants' building. Once the high carbon emission period started, the precooling ended to pass to the shutdown of precooling phase ('start of pause') where the internal temperature increased until its original temperature at the end of the DRE ('end of pause'). Since then, the HVAC behaviour is the daily normal.

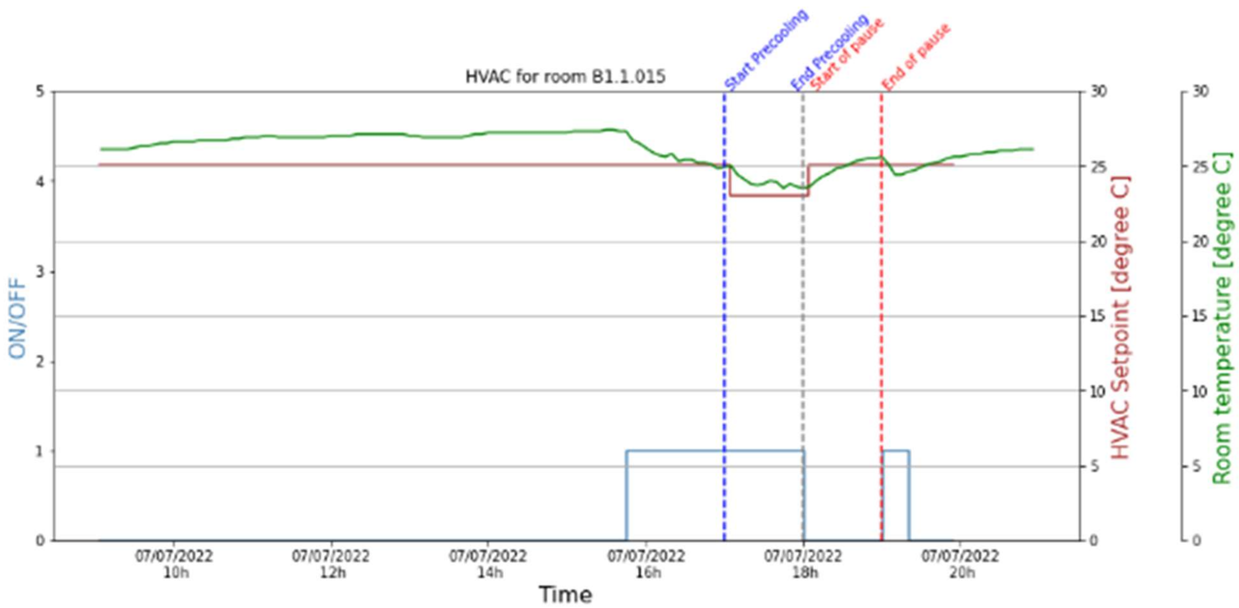


Figure 8 Setpoints and Room Temperature (room B1.1.015) for DR Trial

One aspect to consider is that in both trials the possibility of not performing at DREs can occur due to no decrease in tariffs or CO_2 emissions in the time range defined. Such case is expected sometimes and is not a drawback, there simply will not be load shifting that day.

3.1.3. Demand Response – Energy Savings

The elimination of wasted energy on conditioning during non-occupied periods is the main objective of this trial. To achieve this, the behaviour of the building occupants was analysed to define the period when there is no activity (such as lunchtime or the end of the working hours) by the data consumption of smart plugs. Once, these periods are concreted, the HVACs will be switched off one hour before the period of non-occupancy occurs so that the thermal inertia of those last minutes or hour in which activity is taking place do not affect the occupant's comfort, and the same applies to the period at the end of the working day.

In the first case, once the activity starts again, the devices will be switched on. In this way, energy savings were achieved by taking advantage of those short moments when there is no occupancy.

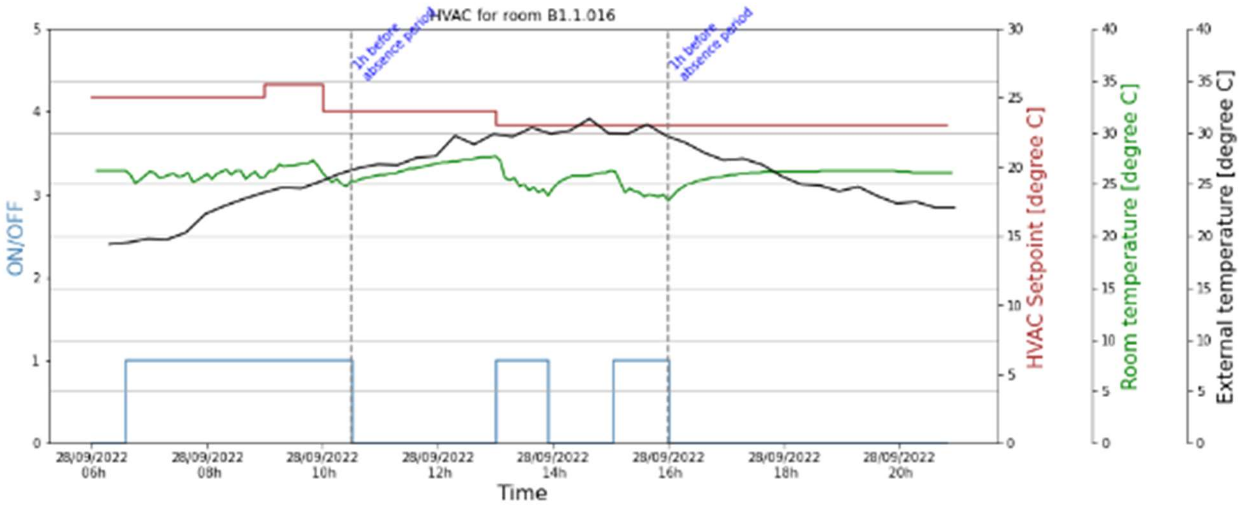


Figure 9 Setpoints and Room Temperature (room B1.1.016) for DR Energy Saving Trial

The evaluation of the user's behaviour for a complete day of working hours was done by using the data consumption obtained from the smart plugs as it was explained above. One hour before the users leave the rooms, the HVAC is turned off, and it will be turned on when they come back. Like the rest of the trials that correspond to DRE, this one will be performed again in winter season.

3.1.4. Occupants' feedback

The trial consisted of the validation of the smart actuations and suggestions approved by the user.

Questionnaires were sent to the occupants before and after the DREs to obtain occupant feedback on whether and how the user's comfort was interfered with or modified.

The questionnaires have already been completed for the summer season and the remaining ones will be done in the winter season, where the next round of the trials of DRE will be carried out. That is why there are two versions, one for the DRE by load shifting during cooling system and the other one with the heating system by following the same designed model, adapted to each seasonal period. Two questionnaires were sent out, the first before trials 1 and 2 and the second after trials 1 and 2. The questionnaires focused on thermal comfort and user acceptance of these actions.

3.1.5. Ventilation control

The implementation of the ventilation control trial will be based on changing the thermostat set-point according to the CO_2 level in the room. Thus, if it is high, the ventilation shall be activated, if it is low, it shall be deactivated. Coordination with S5 will take place to carry out this trial during the autumn season.

3.1.6. Crowdsensing

Democratisation of the thermostat by applying crowd-sensing will be achieved in this trial. It will be based on the occupants' preferences and thermal sensibility final decision of how they prefer the set-point temperature. To analyse this information, the design of a system to recollect what the occupant prefers is under development.

3.1.7. Spanish (UMU) Trial Summary

Trial Number	Trial name	Status	Month of trial launch	Description	Relevant KPIs
1	DR strategy for flexibility extraction - Tariffs scheme	Summer season: completed Cooling season: to perform	M28/M29	DR events will be sent to device controllers to shift consumption from high tariff periods to medium or low	LoS
2	DR strategy for flexibility extraction - Renewable scheme	Summer season: completed Winter season: to perform	M28/M29	DR events will be sent to device controllers to shift consumption from low renewable generation periods to high	LoS

3	DR strategy for energy saving	Summer season: completed Winter season: to perform	M28/M29	DR events will be used to obtain energy saving by managing the set-point temperature of the HVAC	TES
4	Occupants' feedback	Summer season: completed Winter season: to perform	M28/M29	Validate that the smart suggestions approved by the occupants fulfil the targets in occupants' comfort and convenience	TES UA PRt
5	Ventilation Control	Trial in progress with preliminary KPIs	M25-M26	Ventilation control based on the level of CO2 detected	ISoB PRt
6	Crowd-sensing	Trial in progress with preliminary KPIs	M25-M26	Democratisation of the thermostats: occupants can express their preference for the set-point temperature	TES UA PRt

Table 1 Summary of UMU Trials

3.2. Greek Pilot (KaMa)

The installation period at the Greek pilot site was finalised on the 29th of September, upon the deadline that had been set by the pilot manager, allowing all sensors and controlling devices that were originally planned to be placed at the building to be accommodated. Progress on this aspect has been thoroughly reported in internal biweekly/ monthly progress reports of WP 7, MS7 report, Project's biannual progress reports and Deliverable 7.2. The successful installation of the devices and their proper integration with the PHOENIX platform were milestones for trials period initiation at the Greek pilot site. Table 2 summarises the status and other important details of all PHOENIX trials that take place in the Greek pilot site. Until the present moment (end of October), the status of the trials is as follows: one trial is finished (trial No 1), four trials are initiated, running but not finalised yet (trials No 3, 4, 5, and 6), and three trials are not initiated yet (trials No 2, 7, and 8). The reason for the non-initiation of the three trials is that they require the launching of the dashboard in order to be executed (dashboard is a milestone), but of course, they have thoroughly been designed and are ready to be performed as soon as the dashboard is launched in the interventions.

3.2.1. Integration of devices

This trial is concerned about the successful integration of the devices to the PHOENIX platform. Since the devices have been implemented at batches, their verification has been performed accordingly. At least one week of continuous data retrieving has been achieved for both legacy and new equipment. The devices that exist in the Greek pilot site have either Modbus/TCP or Z-wave communication.

In more detail, as far as the Modbus devices are concerned, their connectivity was first confirmed by the "Modbus Master" utility by reading the proper registers. An example for a single-phase smart meter with the ID 18, which corresponds to an electrical device of one of the eight apartments, is seen in Figure 10a, and example of one of the two PV inverters in Figure 10b.

As far as the Z-wave devices are concerned, their connectivity status was first verified by the "node-red" tool by clicking on each node and retrieving all the information they include in their properties. An example of the readings for the multisensor that is placed inside the building and a thermostat that is placed in one of the apartments is shown in Figure 11. After the initial checking of devices' integration, the validation of the devices' integration occurred, that was achieved by reading what is stored in the context broker. All the installed devices have passed successfully the integration validation test, for which the criterion is "no missing data points".

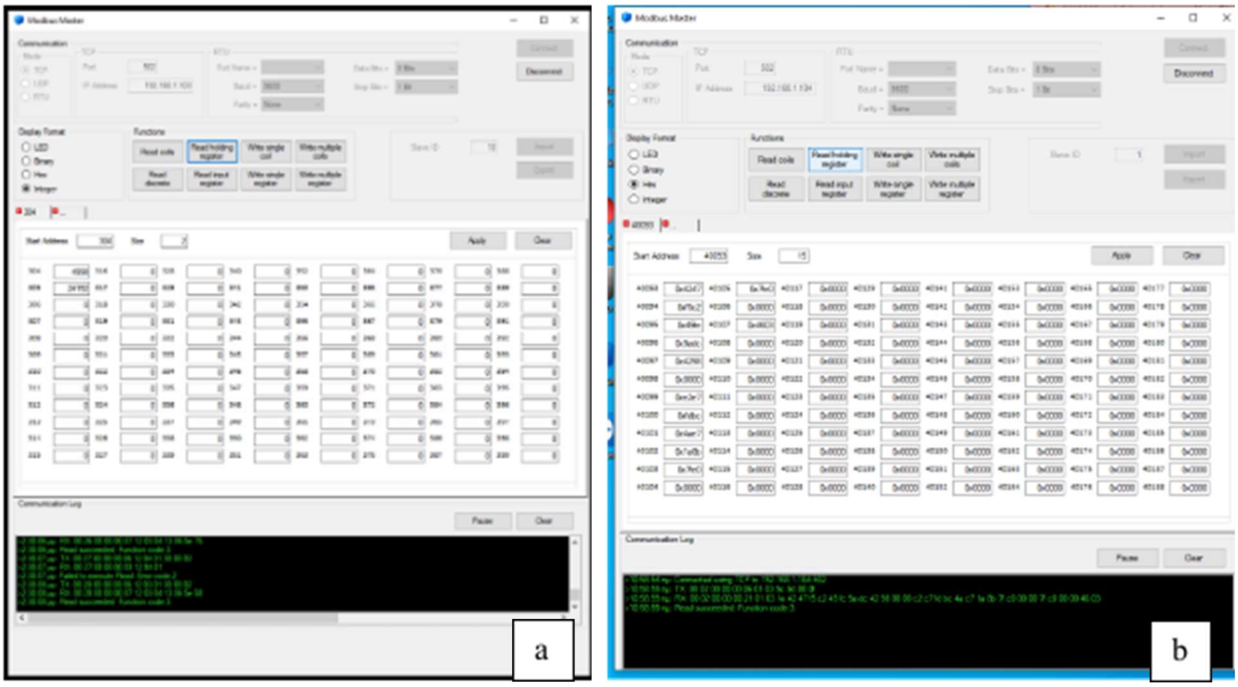


Figure 10 Screenshots of Modbus Master (a) for a smart meter with ID 18, (b) for the inverter Symo20.

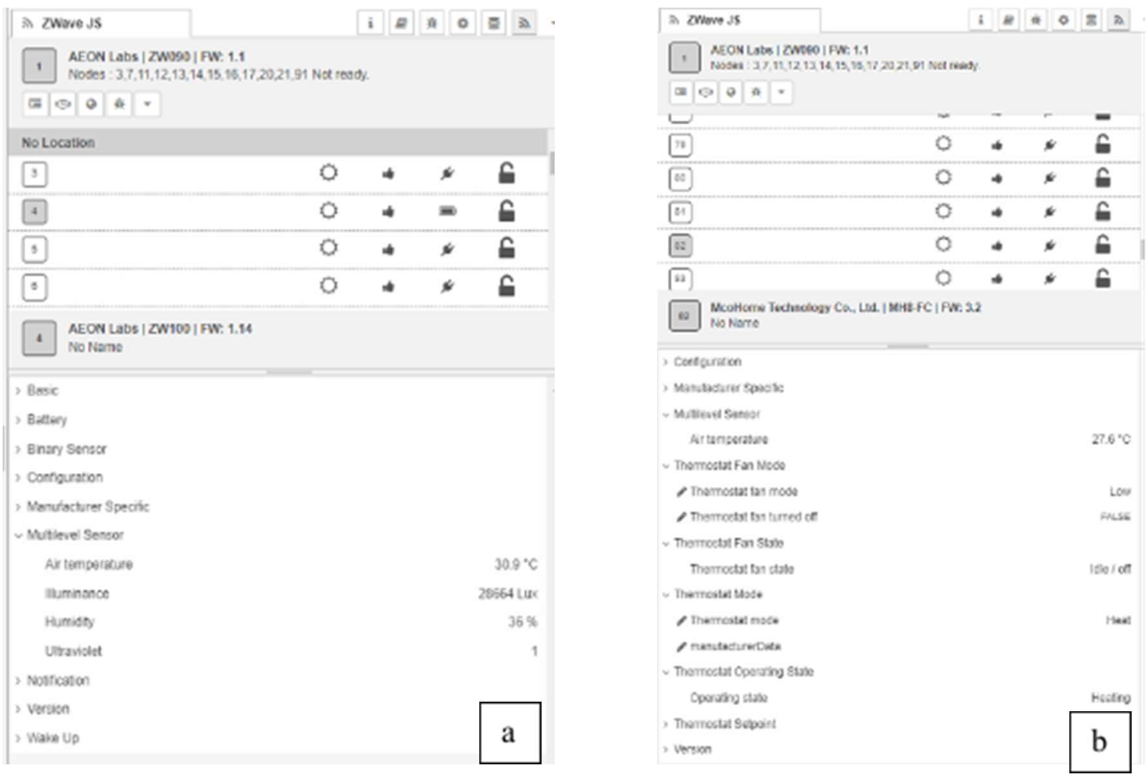
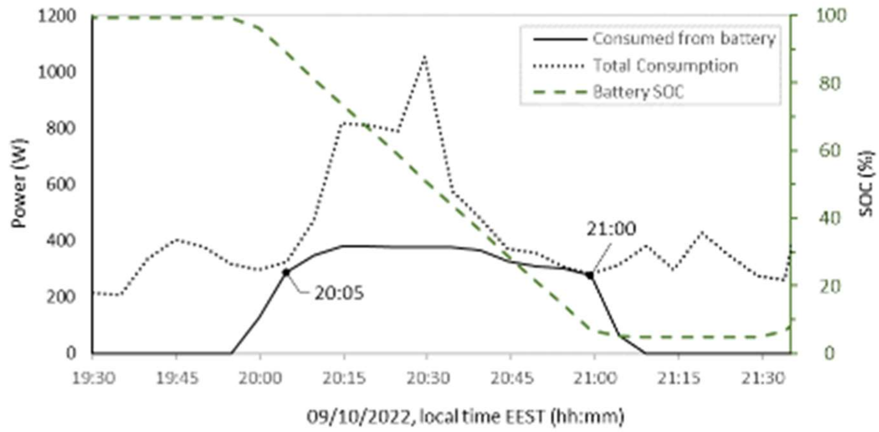


Figure 11 Screenshots of node-red (a) for the multi-sensor with ID 4, (b) for a thermostat with ID 82.

Moreover, as some of the devices allow actuation, additional tests have been performed for them as well to confirm its successful integration. More specifically, there has been performed an actuation test in one of the Z-wave thermostats of one apartment during which the parameters “temperature set point”, “operating state” and “fan speed” where altered successfully via the PHOENIX platform with a delay of a 3-4 seconds between the execution of the command and the actual change in the device. This delay is totally acceptable and exists because of lag in the communication within the local network.

In addition, an actuation test has been performed in the battery during which several commands were sent via the PHOENIX platform to confirm its successful integration. Recordings from three indicative tests are shown in Figure 12 and the main aim was to set the battery at charging and discharging modes whenever needed. In the first actuation test, which was performed on the 9th of October (Figure 12a), the battery covered 62% of the building’s needs within the hours 20:05 and 21:00 (local time). The total energy consumed by the battery at that time, between 19:55 and 21:15, was 5.1 kWh, which is the maximum capacity of the device, and the battery at that test was discharged up to the minimum state of charge, which is 5%. In the second actuation test, which was performed on the 11th of October (Figure 12b), the battery covered 91% of the building’s needs within the hours 23:15 and 00:05 (local time). The total energy consumed by the battery then, between 23:10 and 00:20, was 4.3 kWh. During this test, the battery discharged until 17% state of charge and then started charging from the grid, due to the settings that were chosen at that time. That is the reason why the maximum capacity was not reached at this test. However, it seen that due to the low energy demand of the building at that time, the battery managed to cover a high percent of the building's needs. Similarly, in the third actuation test, which was performed on the 13th of October (Figure 12c), the battery covered 94% of the building's needs within the hours 18:05 and 19:05 (local time). The total energy consumed by the battery then, between 18:00 and 19:10, was 4.3 kWh. During this test, for most of the time when the building was utilizing the battery to cover its needs, there was no need for supplementary consumption from the grid, until only during the last 10 minutes before the battery was completely discharged at which point the state of charge (SOC) was 4%.

The successful fulfilment of this trial is a milestone for the execution and finalization for the rest of the trials, and therefore is related to all pilot's KPIs.



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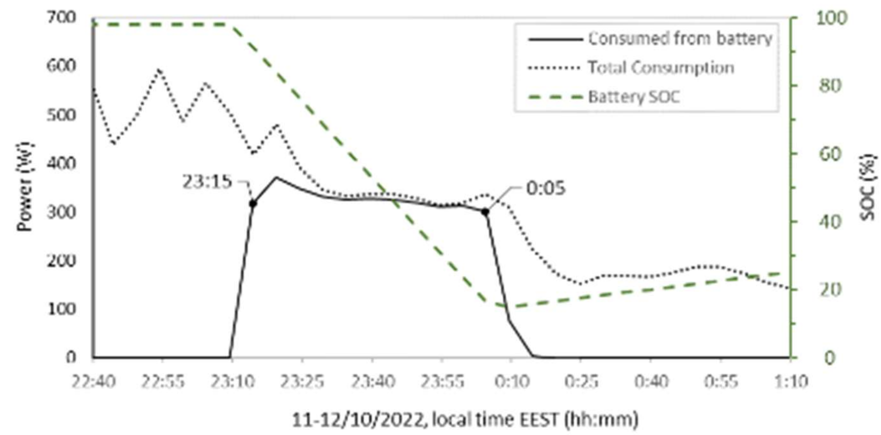

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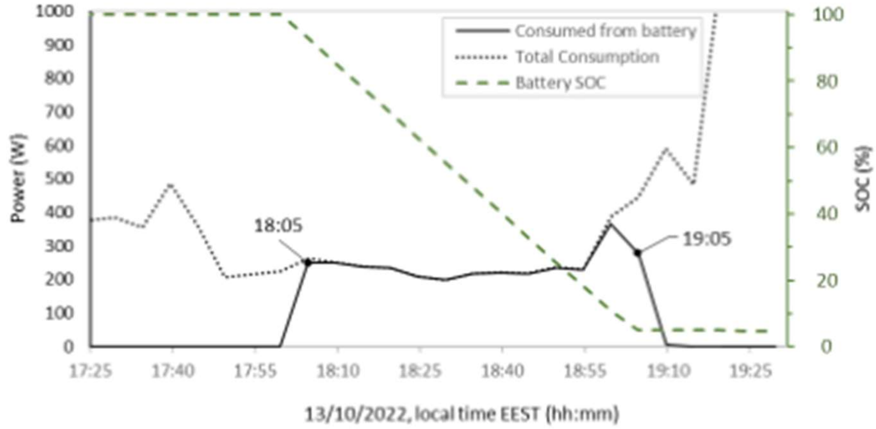


c

Figure 12 Energy consumption results from actuation tests with the battery (a) on the 9th of October, (b) on the 11th of October, and (c) on the 13th of October.

3.2.2. Resident's engagement

This trial assesses whether the users use the dashboard or not in their everyday life, how often and how much time they spend on it. This is easily measured directly from the dashboard, so when the users create their account and start using the platform, their engagement can be measured. A relative service is provided for exactly this purpose, to count the number of logins of the users per day.

User's engagement with the dashboard is important for PHOENIX's smooth implementation in the Greek pilot because its implementation is based on suggestions and recommendations that will be sent to the users through it. Based on several parameters, such as weather data, forecasting algorithms for consumption and production, simulated dynamic prices, and information from all the PHOENIX Modbus and Z-wave devices, the residents will receive notifications and suggestions for actions for all the services that PHOENIX provides. As a result, the KPIs that count on the usage of the dashboard by the residents are the Total Energy Savings (TES), the Energy Cost Reduction (ECR), and the Increased Residents' Satisfaction (IRS).

3.2.3. Black-out support

This trial is related to the battery actuation tests that have been performed within the framework of trial No.1, but also to the flexibility test that have been performed within the framework of trial No.5 (described below). So far there has been confirmation that the battery is responding well to the various commands sent by the algorithms. However, a few more tests are necessary to finalize the procedures and the settings that need to be applied to the battery to prioritize actions.

During this trial, the services that PHOENIX will provide to the building occupants, which will be sent to them via the dashboard, are two: a real time update, when the blackout is detected, and proper suggestions to decrease their consumption to the minimum until the electric power is back on. Once the trial with the artificial black-out is performed (electricity feed from the grid will be manually stopped), it will validate the value of the KPI, Black out Support (BoS).

3.2.4. Electric vehicle usage

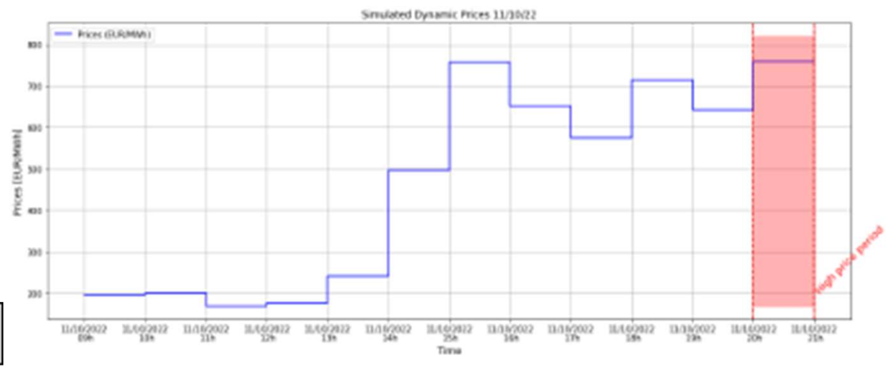
This trial is related to forecasting algorithms, as it is concerned about the driver's habits (when the EV is charged) and the projections of both solar energy production and building's energy consumption. As a result, EV behaviour is going to be simulated as a trial for the EV usage. At the moment there exists one EV charger at the Greek pilot site premises, but none of the residents has an electric vehicle to perform real tests. As a matter of fact, it doesn't make any difference if the usage of the EV charger is simulated or real because the impact on energy is very specific. Therefore, the service for this trial, which is the optimization of EV charging, can be achieved without a real presence of an EV.

There is one KPI related to this trial, Usage of Electric Vehicle (UoEV), and it will be succeeded even with the simulated charging of an EV, as soon as it provides evidence that the Greek pilot site can support the existence of an EV and it has been integrated within the PHOENIX solution and will be emulated with the rest of the components, while the algorithms will recommend convenient and flexible charging program depending on the user's habits, the rest of the energy consumption projections and the production forecasts.

3.2.5. Simulated dynamic pricing

This trial is performed under simulated variations of energy prices at hourly basis, as energy still has a fixed price for the end consumers in Greece. As a result, this trial utilizes these simulated dynamic prices to perform two types of control.

One type of control for this trial is the direct control of devices via the flexibility engine and includes the following procedure: The energy dynamic pricing in conjunction with PV production triggers when energy is consumed from the battery or from the grid, and accordingly when the battery is charged from the grid or from the PV production. So far, two flexibility tests were performed, one on the 11th and one on the 12th of October 2022, during which the flexibility engine started to discharge battery when the electricity price was high. Figure 13 shows the energy price variations for these two dates. For the first trial the battery was set to DISCHARGE mode for one-hour period at 20h-21h, and for the second for one-hour period at 17h-18h. After the one-hour usage, the battery went back to AUTO mode at both trials, so as to return to the usual mode of operation and charge the next day with sunlight from the solar panels. Results from these two trials are presented in Figure 14, where the values of the battery state of charge, the battery's set point for the minimum allowable state of charge (when it is set to the minimum, 4%, the inverter does not allow the battery to get charged and when it is set to the maximum, 100%, the inverter does not allow the battery to stay discharged) and the operating mode of the battery can be seen. For both cases the battery got discharged at the exact time that the flexibility engine instructed. In this way the building utilized for one-hour energy produced by the sun before, at hours when there was no sun anymore and the energy prices were high.



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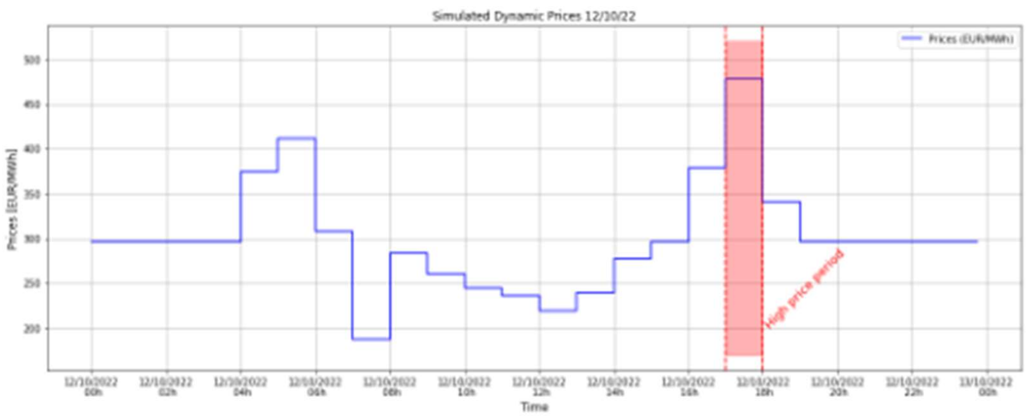

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Figure 13 Simulated dynamic variation of energy prices for the Greek pilot (a) for the 11th and (b) for the 12th of October 2022.

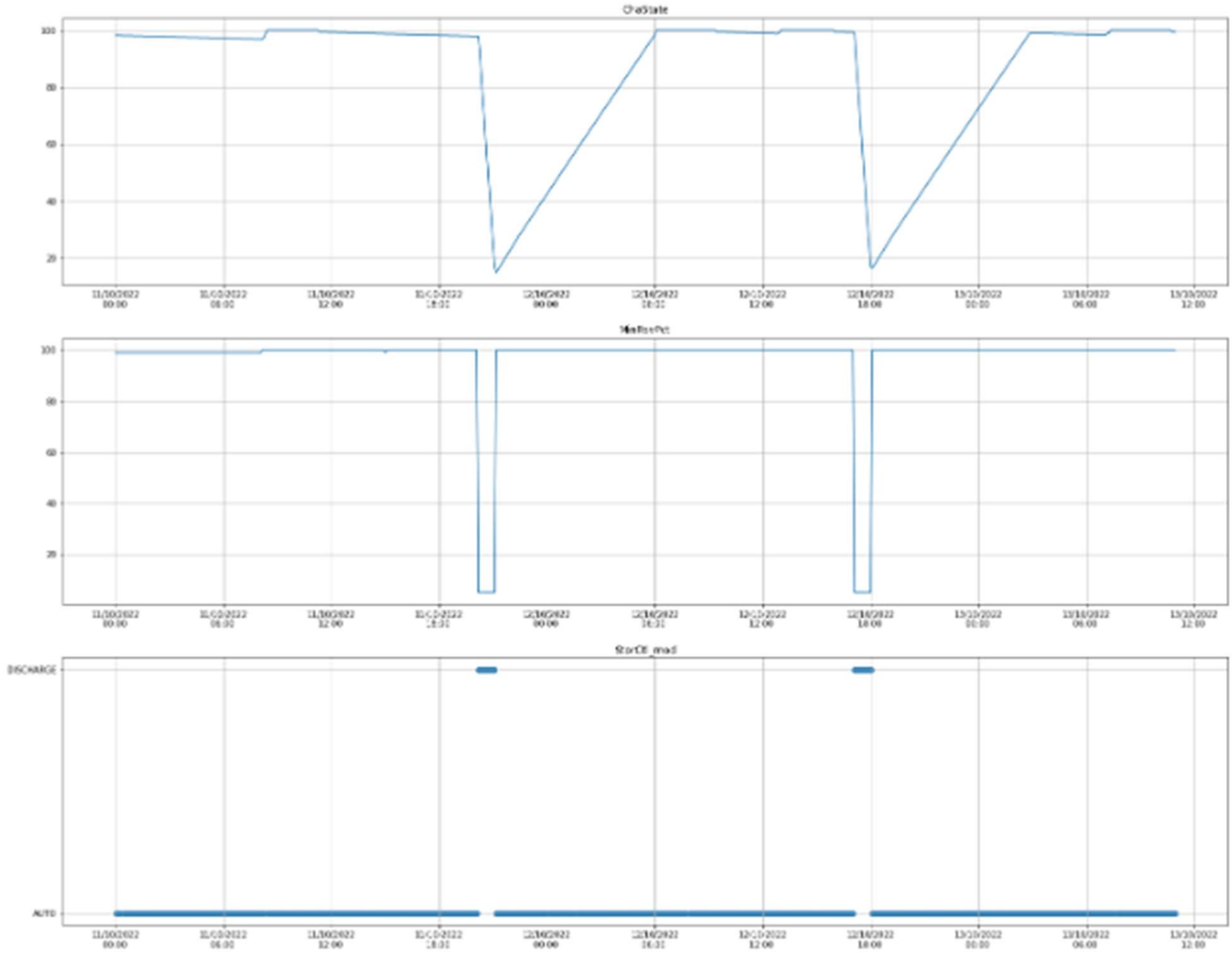


Figure 14 Values of the registers of the hybrid inverter (Fronius GEN24) related to the battery (a) the state of charge of the battery (b) the minimum allowed state of charge, and (c) the operating mode of the battery.

The other type of control for this trial is the indirect control of devices via the dashboard by sending recommendations to the users about changing the settings of their devices, and includes the following two respective procedures: The first has to do with the thermostats of the apartments, for which the indirect control provides suggestions to the users to change the set point of the temperature controller of the heat pump of their apartment (different suggestion for summer and for winter period), taking into account energy dynamic pricing and weather data. The second has to do with the LED bulbs and the dynamic envelops of the apartment, for which the indirect control provides suggestions to the users to save energy by changing the state of the lamps and the dynamic envelopes taking into account energy dynamic pricing and luminosity from the building's multi-sensor. This part of the trial requires the implementation of the dashboard as a milestone, in order for the recommendations to reach the users.

This trial will facilitate the reduction of the cost of energy, mainly due to the direct interventions to the battery charging and discharging, but also with the recommendations provided to the users for energy savings, for the purposes of the KPI Energy Cost Reduction (ECR). So far, the direct control of the battery via the flexibility engine has proven to be a useful tool for decreasing the energy cost related to the consumption from the grid, without the residents to change any habits of consumption. This change of habits is going to be addressed with the indirect control of the thermostats during a second test of trials in the coming period.

3.2.6. Forecasting algorithms

This trial includes basically the evaluation of the projections for energy production and consumption at the Greek pilot by the forecasting algorithms developed within PHOENIX framework. The data analytics service is under development by the technical partners and as soon as it is launched, it will be easy to be compared to the real values, so as to get the deviations and possible improvements through corrective actions, based on users' habits.

The forecasting algorithms will help to advise the users (send recommendations via the dashboard) on how to save energy and decrease the respective cost of energy to ultimately contribute to reach the pilot's related KPIs, which are Total Energy Savings (TES) and Energy Cost Reduction (ECR).

3.2.7. User acceptance of smart controls

This trial is performed in order to evaluate if the residents follow the recommendations provided by the platform that are related to the PHOENIX energy services. This process will be easily materialised by combining information gathered from the dashboard with the real values of the properties of the various devices that are being monitored by the context broker. In this way it will be validated if the residents, for instance, changed the set point of their thermostat when they were advised to, if they turned their lights off, etc. In addition, another tool that will be available in the dashboard is the evaluation of the recommendations by the users, who will be asked to vote whether it was useful for them or not. In this way, the algorithm will be able to further adapt to the user's preferences with the help of the feedback from users PHOENIX's service.

The dashboard and the retrieved data from the PHOENIX platform will show if the smart suggestions are approved by the residents and if they fulfil the targets in energy consumption reduction, in relation to the KPIs Total Energy Savings (TES) and Energy Cost Reduction (ECR).

3.2.8. Comfort and convenience

This trial is performed to evaluate if the residents follow the recommendations provided by the platform that are related to PHOENIX non-energy services. So, the approach of this trial is the same as the one of trial No.7, with the only difference that the aspects involved here can be only qualitatively evaluated. So, for this trial a questionnaire will be developed, unified for all pilots, and will be distributed to the building residents as soon as they start using the dashboard and get comfort and convenience notifications. The goal is to evaluate if the smart suggestions approved by the residents fulfil the targets in residents' comfort and convenience, without compromising the goals for energy and cost savings. To this direction, the tool of the voting the usefulness of the recommendations via the dashboard will be applied at this trial, as well, with the help of the feedback from users PHOENIX's service.

This trial will provide useful information for the improvement of the KPI related to resident's satisfaction (Increased Residents' Satisfaction, IRS), but also for the Total Energy Savings (TES) and the Energy Cost Reduction (ECR).

3.2.9. Summary of Greek Pilot

No	Trial name	Status	Month	Description	KPIs
1	Integration of devices	Trial completed and KPI Demonstrated	M23-M25	All devices are connected successfully to the gateway and communicate with the platform	all
2	Resident's engagement	Trial Planned	M27- M28	Check if the residents follow the suggestions of the dashboard	TES, ECR, IRS
3	Black-out support	Trial in progress with preliminary KPIs	M26- M27	Induce artificial blackouts to assess whether the battery can supply critical loads.	BoS
4	Electric vehicle usage	Trial in progress with preliminary KPIs	M25- M28	Simulate the usage of an EV car (or if necessary, rent an EV and provide it to one resident)	UoEV
5	Simulated dynamic pricing	Initial trial complete and KPI Demonstrated	M24- M27	The algorithm decides when to store energy, when to consume from the grid and when from the battery, depending on the simulated dynamic pricing	ECR
6	Forecasting algorithms	Trial in progress with	M26- M30	Compare forecasting results to real data as regards energy production and consumption	TES, ECR

		preliminary KPIs			
7	User acceptance of smart controls	Trial Planned	M27- M28	Validate that the smart suggestions approved by the residents fulfil the targets in energy consumption reduction	TES, ECR
8	Comfort and convenience	Trial Planned	M27- M28	Validate that the smart suggestions approved by the residents fulfil the targets in residents' comfort and convenience	TES, ECR, IRS

Table 2 Summary of Greek Pilot Trials

3.3. Irish Pilot (ARDEN)

In order to connect with the PHOENIX platform, carry out trials and deliver on the pilot's objectives, it was necessary to fully integrate read and write access to the BMS at the commercial pilot site. The barriers to integrating legacy BMS systems with third party platforms are well documented and include closed proprietary legacy systems, resistance to change in the incumbent BMS providers and lack of support and engagement from BMS system integrators. These barriers delayed the full integration of the commercial site especially for write access and actuation.

The majority of Arden's concern over the last period has been focused on finalising actuation of devices at the commercial pilot site following the completion of D7.2. The actuation for the domestic sites has been completed and the commercial actuation has been completed, tested and trialled. We organized many meetings with BMS systems integrators and project partners and our development team to breakdown the difficulties we have been facing. The process consisted of installing API interface software and middleware to facilitate access via the MQTT broker. We manually successfully carried out GET commands for each device to learn the current values of each device and the corresponding set-points. We then tested PUT commands have also been carried out and unsuccessful commands were identified and remedied. These commands were then coded in middleware to interface between the MQTT broker and the BMS API. The lack of support from the BMS service provider and the lack of a useful manual complicated this process.

Following this delay, the Arden pilot is making good progress on implementing and accelerating the trial plan to remain on schedule. PHOENIX services including grid flexibility comfort optimisation and smart billing have been rolled out and Arden is keeping track of any difficulties or complications faced during the rollout.

Arden fully integrated legacy devices at pilots with the PHOENIX platform and have successfully completed a number of trials. The remainder of the trials have all been started, many since the beginning of the project. Smart billing, which Arden is quite eager to have rolled out for pilot sites, has been implemented in the pilot sites. Arden is working closely with UMU and other partners to coordinate the most successful way to rollout smart billing as well as demand response. The first calculation from historical data for the evaluation of cost benefits for each pilot site has been carried out. Similarly for the evaluation of comfort and convenience as well as the evaluation of flexibility at each pilot site.

3.3.1. Validate successful integration of devices

This was the first trial finalised by Arden. In the case of the Arden pilots, all devices had been installed at the pilot sites prior to the PHOENIX project. In order to integrate the devices at the commercial pilot site with the PHOENIX platform, middleware was installed to connect the Delta Controls BMS on site with the PHOENIX platform. This made it possible to connect to the sensors and actuators already existing in the commercial building. The data being sent via the BMS was validated by comparing it to historical energy bills.

For the two domestic sites, hardware was installed to enable device connectivity to the PHOENIX platform. A MyEnergi home portal was installed at each domestic site and middleware was also installed to connect the MyEnergi portal to the PHOENIX platform.

This trial was associated with the integration of equipment and energy consumption shared (IoE) KPI. It was important that this KPI was realised as having a full understanding of a building's energy consumption is a goal for the project.

3.3.2. Validation of cost reduction benefits comparison between baseline and PV at Domestic Pilot #1

The first step in validating the cost reduction benefits of enhancing PV generation was establishing a baseline energy consumption for the domestic pilot. As mentioned above, the baseline was calculated using energy bills and the floor area of the dwelling. Following this, the need for developing a PV forecast through the utilisation of weather data was recognised. The forecast will allow Arden to predict times of high generation.

The second external data source which will be used during this trial will be Irish Day Ahead Electricity Market data. Based off the DA market prices, PV generation will be used to heat up water at the first domestic site at the most cost-effective times. At the end of the month, consumption will be compared and is expected to be reduced when compared to previous months, thus verifying the cost reduction benefits against the baseline.

Arden conducted a preliminary trial diverting excess solar PV generation to hot water generation during the summer months. Prior to the trial some 9 kWh per day or 76% of total generation was exported. During the trial all electricity was used for water heating successfully achieving 100% self-consumption.

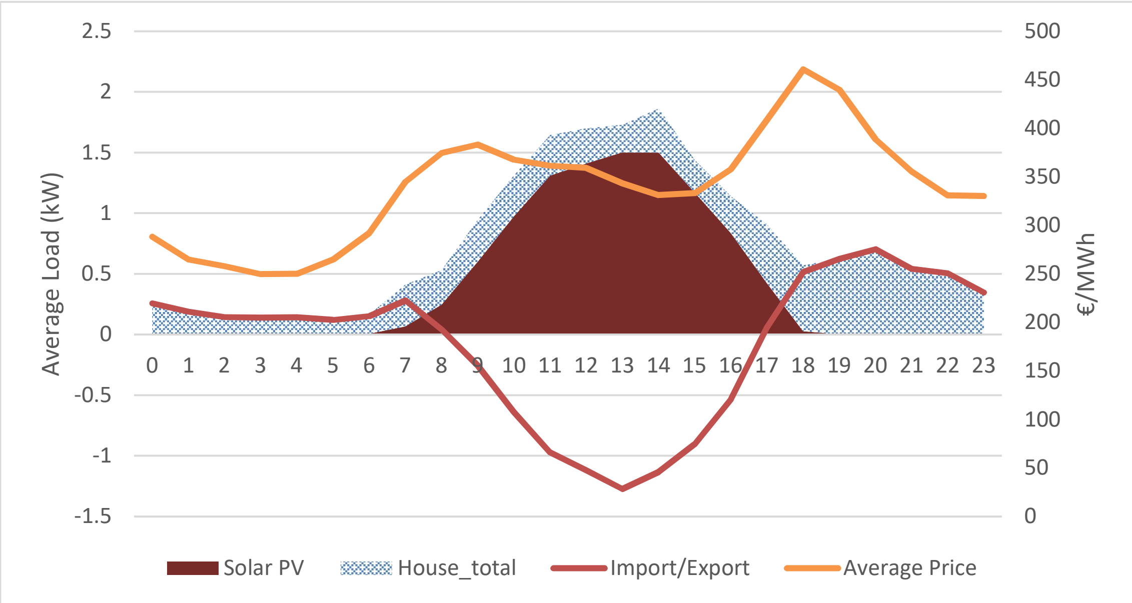


Figure 15 – Time of Use Consumption, Solar PV and Export for Irish Domestic Pilot #1

The main KPI that this trial addresses is energy cost reduction of over 30% (ECR). The trial alone does not aim to reach a reduction of 30% but to contribute to the goal. The remainder will be achieved through the other services applied through PHOENIX.

3.3.3. Validation of cost reduction benefits comparison between baseline and smart controls

Similarly to the previously discussed trial, the first step to this trial was to establish a baseline at both pilot sites. The baseline for the second domestic site was calculated in the same way the baseline for the first domestic site was. For the commercial site, there was more extensive historical data available. This allowed us to calculate a baseline using weekly heating degree day data as well as historical consumption data collected and stored on the onsite BMS. Once again, the Day Ahead market data collected by the PHOENIX server will be utilised in this trial.

For the Domestic #2 pilot site, the smart controls established due to interventions through the

PHOENIX project were to enable control of EV charging via the PHOENIX platform. Arden plans to utilise the DA market data to determine when is the most financially and energy efficient time for the occupant to charge their EV. Times of low or negative pricing (usually during the night) will be the most beneficial for the occupants. During these times prompts will be sent to schedule charging of the EV. Consumption during the trial month will be studied and compared to the baseline to validate cost reduction benefits. Figure 16 shows the baseline average consumption for EV charging and other uses compared to an average load profile and the average time of use pricing based on the DAM prices. This provides the basis for evaluation of load shifting trials in the Irish Domestic Pilot#2 and indicates the scale of the potential opportunity through load shifting.

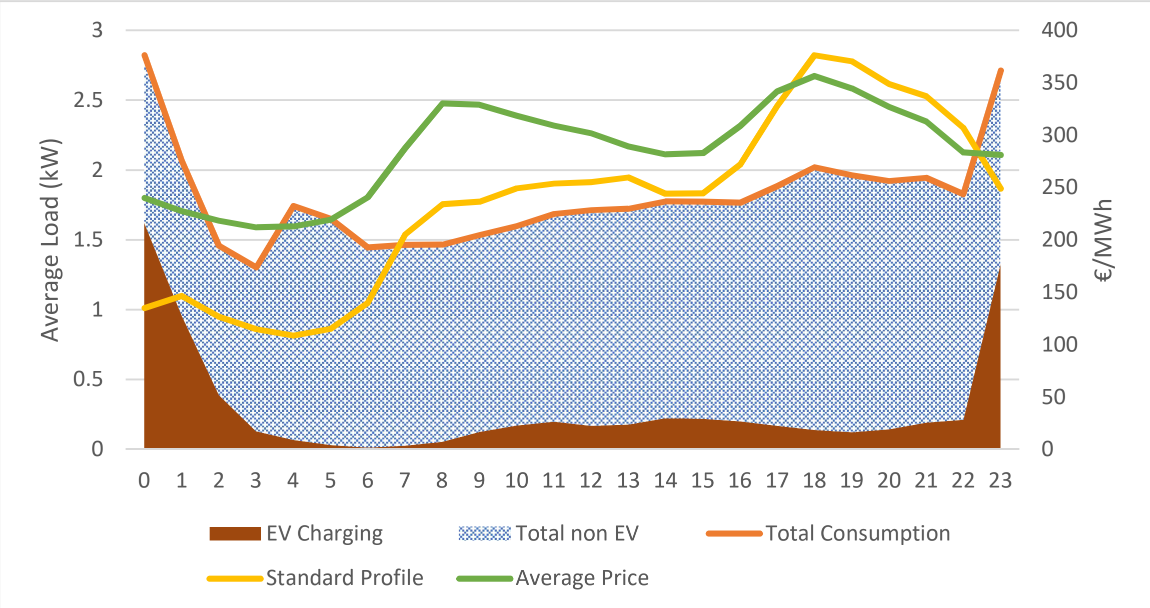


Figure 16 – Time of Use Consumption and Costing for Irish Domestic Pilot #2

A similar model is used for the trial at the commercial site albeit with more complexity, more options to schedule and optimise consumption. Actuation has been finalised for the legacy devices at the commercial site. The CHP and heat pump can be sent "active" and "inactive" commands to turn the devices on and off. By employing DA market data, Arden will use this actuation to turn on either device when space heating is needed during periods of high energy pricing.

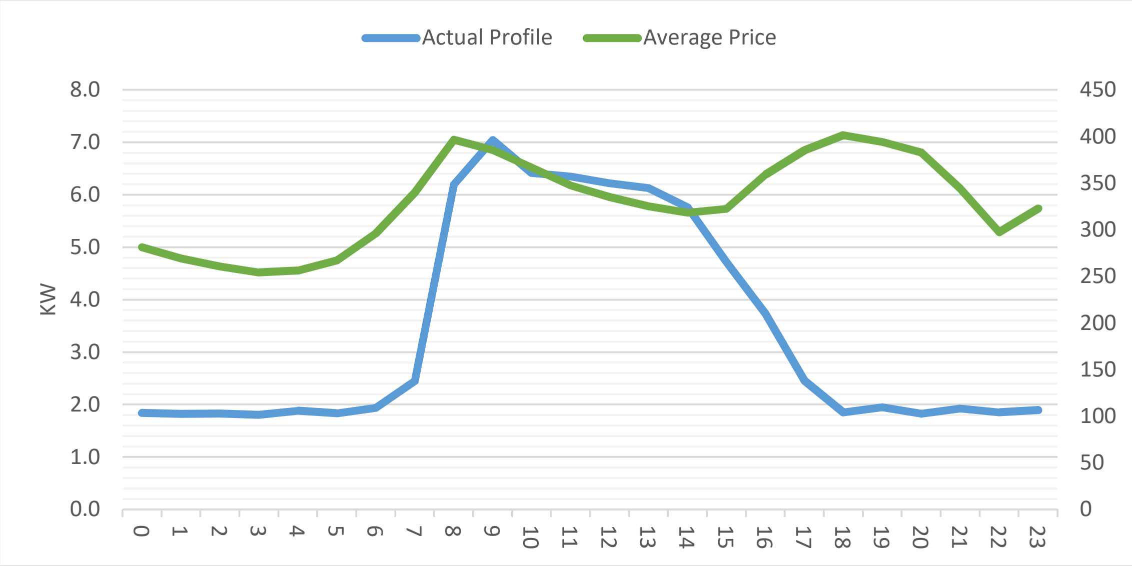


Figure 17 Baseline Consumption in the Irish Commercial Pilot

The CHP and heat pump primarily provide energy for space heating so the main trial will take place during the winter months with a higher space heating demand. The trials at both pilot sites will study and promote time-of-use consumption and tariffs. The main KPIs being evaluated during these trials are improved smartness of buildings as per smart readiness (ISoB), energy performance measured (EPM), integration of equipment - energy consumption share integrated (IoE) and reduction on peak demand from utilities point of view aiming for a 35% reduction (RoPD).

3.3.4. User acceptance of smart controls

To determine the best way of measuring user acceptance, Arden studied the paper published by UMU on demand response. The main indicator for user acceptance detailed in the paper was if the demand response signal was overwritten by the occupant. Thus, while Arden is carrying out the trials to evaluate cost reduction benefits by utilising smart controls, we will also study if the demand response commands are overwritten by occupants.

Another method we will employ to measure user acceptance will be via the collection of data through the PHOENIX website. Arden will compile user login data from the website. User login indicates acceptance and user interest. User action will also be gathered and noted and will also give an insight into user acceptance.

The third method Arden will apply to measure user acceptance will be the dissemination of surveys to pilot occupants. Two sets of surveys will be developed, one for domestic occupants and the other for commercial. The surveys will be sent to domestic occupants following the implementation of the validation of cost reduction trials. For the commercial pilot, a QR code will be set up and put around the pilot site to allow occupants to have their input on how they have found the smart controls.

The first KPI addressed during this trial is the total target energy saving of 20-30%. Measuring user acceptance will allow us to predict total energy saving more accurately as if user acceptance is low there will be a low impact of the PHOENIX services on energy saving. User acceptance (UA) and people reached through training and awareness (PRt) are two similar KPIs associated with this trial. Arden has carried out training days with the pilot sites to inform them of the information available to them and the execution of trials. To date trials have been limited to highly monitored interventions at pre-planned time periods to foster confidence and user acceptance. This has ensured that trials can be carried out without compromising user comfort or the delivery of energy services to the pilot buildings. Before longer term trials take place, Arden will host further training with the occupants of each pilot site. The final KPI approached through this trial is comfort feedback (CF) which is targeted to be 95%.

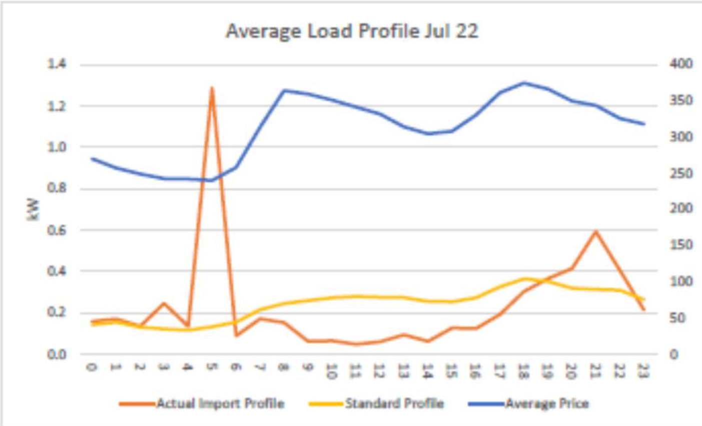
3.3.5. Smart Billing

Smart billing is being deployed at every pilot site. This process will involve the employment of time of use tariffs. Currently in Ireland, energy bills are based off flat 24hour rates or a flat day and a flat night rate. For the trial, Arden produces two bills. One applie flat rates that the pilots are currently being charged. The other is a “smart” bill.

In order to produce these smart bills, Arden will make use of the flexibility engine developed by UMU. The DA market data is applied to the bills. Consumption data is being continuously collected with time stamps and relayed to the PHOENIX platform. The consumption is charged based on the tariffs from the DA market for the time in question. With optimisation of renewable generators as well demand response events being carried out at the same time as this trial, Arden is confident that the smart bills can be significantly lower than the bills produced using flat tariffs. Smart bills are being generated monthly for all Irish pilot sites to provide information on consumption, time of use pricing and to incentivise and reward load shifting as described in Section 3.2.

arden energy

Smart Bill for Dom #1 Jul 22



Electricity Consumed (kWh)	182
Standard Bill Energy Cost	€60.46
Smart Time of Use Energy Cost	€56.27
Load Shifted by controls (kWh)	34
Load Shifted by controls (%)	21%
Cost saved by shifting load	**€4.19**
Cost saved by shifting load	**6.9%**

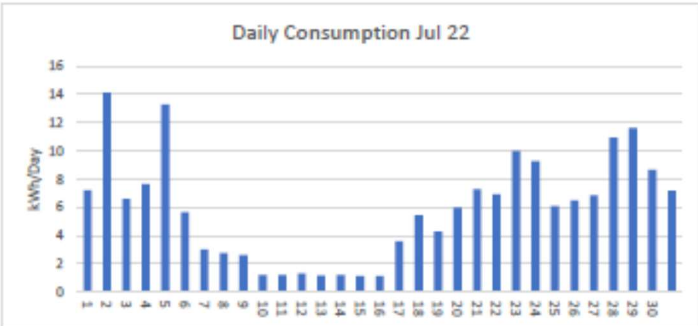


Figure 18 Smart Bill for Irish Domestic Pilot #1

Figure 18 shows a smart bill showing the results of a trial shifting hot water heating load from daytime to a period between 5am and 6am and communicating the benefits and savings to the householder. In workshops and training sessions with Pilot sites, concern was expressed over potential increased costs in smart tariffs so a clear means of communicating the benefits (or otherwise) of smart tariffs was designed. A visual graphic shows the baseline flat tariff profile, the actual (after intervention) profile and the hourly cost. The load shifted and the associated cost savings are then reported together with the bill total. During the remainder of the project Arden will engage with users to optimise smart bill design.

One of the main KPIs addressed in this trial is load shifting (%/ kWh) from high tariff time of use prices to low tariff time of use prices and from low renewable generation to high renewable generation (LoS). Smart billing incentivises load shifting and rewards those who adhere to demand response events set up through the PHOENIX platform.

Another KPI associated with this trial is revenue generated from flexibility and trading with savings of around 63€/year/household (RFF). With load shifting being implemented alongside time of use pricing, savings will be generated from the more efficient consumption of energy.

The final KPI included in this trial is the reduction on peak demand from a utilities point of view of around 35% (RoPD). This will be addressed through load shifting and measured by the continuous collection of consumption data.

3.3.6. Evaluation of comfort and convenience

As with most of our trials, to evaluate comfort and convenience, Arden will combine a variety of methods to get a well-rounded view of the topic. This trial will follow the completion of the trials detailed above.

The first measurement will be of the SRI of the pilot sites following the implementation of PHOENIX services. Two SRI calculations have been carried out since the launch of the PHOENIX project. The SRI tool calculates comfort and convenience. The SRI also contains a before and after PHOENIX interventions calculation. This will be a great source to measure improved comfort and convenience and will be utilised by Arden for this trial. It will also indicate the improvements in each building's smartness since the beginning of the project.

While an arithmetic method for measuring comfort and convenience will be very useful in analysing the comfort and convenience of the pilot sites, it is still important to engage pilot occupants and get feedback regarding this topic. In order to improve the comfort and convenience controls of the building envelope were integrated with the PHOENIX platform according to CO2 and temperature for improved air quality and comfort. Similar to how we will measure user acceptance, surveys will be circulated to the pilot sites following the implementation of PHOENIX surveys. The surveys will be dispersed to the pilot sites at the same time as the ones detailing user acceptance to try and not inundate occupants with surveys.

The two KPIs focused on throughout the duration of this trial will be comfort feedback of 95% (CF) and user acceptance of smart controls and demand response (UA).

3.3.7. Evaluation of flexibility

As with the majority of these trials, this trial began with the integration of smart controls of the different legacy devices with the PHOENIX platform. This allowed Arden to enhance the flexibility of each pilot site. At the commercial site these controls are being used to shift loads and control space heating in the building according to demand response signals. Similarly, at domestic pilot #2, demand response signals were used to shift loads at for EV charging. Thus, this trial once again runs in line with the previously discussed trials.

Arden will employ the PHOENIX flexibility engine to enhance the time of use pricing and so improving the flexibility of the pilot sites even more. The aim of this trial is to study how reactionary and efficient the various devices at each pilot can be made. The external sources to be used to determine the demand response actions will be the Irish DA market and weather data.

As with the trial analysing comfort and convenience, comfort and convenience (CF) and user acceptance (UA) are the two KPIs to be addressed.

3.3.8. Self-consumption evaluation

This trial will be carried out at the Domestic #1 pilot site. The pilot had solar PV installed prior to the launch of the PHOENIX project. Through the previously discussed trials, smart controls were installed to optimise self-consumption of PV output for hot water generation. In these trials, control of hot water generation based on solar PV generation was achieved. To maximise self-consumption, the PHOENIX flexibility engine will be utilised. The flexibility engine will rely on external data sources detailed by Arden such as the DA market and weather data. The trial will be carried out during two separate months. The first month was in September, the second will be in M29 to evaluate the effectiveness and the options for winter months. The data collected from these months will collected and compared to the baseline. Furthermore, the trial will increase user awareness with continuous monitoring being carried out.

The main KPI addressed in this trial is revenue from flexibility and trading whit the aim of saving around 63€/year (RFF). Enhanced utilisation of self-generated electricity should result in significant energy savings.

3.3.9. Summary of Irish Pilot Trials

No	Trial name	Status	Month	Description	KPIs
1	Validate successful integration of devices	Trial completed and KPI Demonstrated	NA	All devices connected successfully to gateway, send data to platform and vice versa	IoE
2	Validation of cost reduction benefits (PV at Domestic #1)	Initial trial complete and KPI Demonstrated	M24-M30	During normal operation cost related KPIs are monitored and evaluated in order to measure the economic benefits of the RES and storage installation in the demo site.	ECR
3	Validation of cost reduction benefits comparison between baseline and smart controls	Initial trial complete and KPI Demonstrated	M24-M30	The electricity savings due to smart devices operation is translated into energy costs in order to understand the level of cost savings	ISoB, EPM, IoE, RoPD
4	Validation of cost reduction benefits-comparison with all PHOENIX devices and baseline	Initial trial complete and KPI Demonstrated	M24-M30	The electricity savings due to all PHOENIX devices operation is translated into energy costs in order to understand the level of cost savings	ISoB, EPM, IoE, RoPD
5	User acceptance of smart controls	Trial Planned	M28-M30	Prediction of load switches.	TES, UA, PRt, CF
6	Smart Billing	Initial trial complete and KPI Demonstrated	M25-M29	Employing time of use tariffs for pilot sites	LoS, RFF, RoPD
7	Evaluation of comfort and convenience	Trial in progress with preliminary KPIs	M26-M29	The enhanced smart controls and information provided to building managers and occupants at the Irish pilots will improve comfort and convenience	CF, UA, LoS
8	Evaluation of flexibility	Trial in progress with preliminary KPIs	M26-M29	Optimisation of heat pump and CHP	CF, UA, LoS
9	Evaluation of flexibility	Trial in progress with preliminary KPIs	M26-M30	Hot water is controlled to run at times of lowest market cost	RFF, LoS
10	Self-consumption evaluation	Trial in progress with preliminary KPIs	M26-M30	Self-consumption increase	RFF, LoS

Table 3 Summary of Irish Trials

3.4. Spanish Pilot (MIWEnergia)

MIWenergia has completed the first trial, the installation and integration of the devices. It was started last year, but it was mainly completed during the first semester of 2022. Currently, all devices are properly connected to the PHOENIX platform, although issues arose during this activity as explained below.

Last July, with the support of UMU, trial No.4 "Flexibility extraction" was tested during summer period as an exercise to extract preliminary results and prepare the following iterations to be run during winter period when all lessons learnt will be applied to have a more complete version of the trial.

At the same time, the first impressions regarding the flexibility tests and the platform, have been gathered from end users, to begin with the trial No.2 "User acceptance of smart controls".

3.4.1. Validate successful integration of devices

The process started with the installation of the smart devices deployed to integrate legacy equipment in the PHOENIX platform. The main component for the integration is the raspberry pi that includes the image with the solution developed by ODINs that gather data from the Z-Wave and Wi-Fi devices and allows interact with them. All devices were integrated in the PHOENIX context broker but due to some communication problems, the image needed to be updated, activity that was performed in June (M22).

Another issue that emerged during the trials was that 10 out of 21 HVAC control devices installed to control split units in CEEIC building were not compatible with those units despite the fact that the device should work with any universal HVAC unit with IR control. A remote control was sent to the manufacturer for developing a new configuration for the smart device but after several tests (last one at the end of July, M23), it was not possible to allow communication between the smart control and the HVAC unit although the device is fully integrated in the PHOENIX platform and it can send and receive data and change the settings of the device.

Finally, all viable devices are connected to the platform and fully integrated, so the trial is 100% successful. Nevertheless, the devices need to be checked and supported in order to maintain communication, in case of Wi-Fi failures or any kind of problem with the sensors.

This trial is related to the following KPIs: Integration of equipment - Energy consumption share integrated (IoE) and Improved smartness of buildings as per smart readiness indicator (ISoB).

3.4.2. User acceptance of smart controls

MIWEnergia plans to measure the user acceptance of smart controls with two different methods. The first one is through the PHOENIX dashboard/platform and it's related to users' engagement. The platform has a service implemented that calculates the logins per day. This would capture the acceptance and interest of the users in the platform.

The second method is through questionnaires and surveys after workshops or events. During the flexibility tests, MIWEnergia send a questionnaire developed by UMU that tried to capture user's condition before and after the event and get feedback from the thermal sensation during the test. In this first flexibility tests, 4 answers were collected, with 2 of them with positive or mildly positive responses and 2 answers mildly negative, that will help us to improve for the following flexibility trials. Another way to gather users' opinion regarding PHOENIX solution was through training and awareness workshops. After the event one hosted in CEEIC building in September, 6 answers were collected, with an average result of 4.5 (rates from 0 to 5) that showed the interest of the users about the project and the solution developed. The last actions to evaluate are the comfort and convenience notifications that will suggest the users when to change HVAC conditions to improve their wellness.

MIWEnergia will continue to ask for feedback during the different events, trials and workshops, to be carried out until the end of the project. MIWEnergia aims to obtain at least 80% user's satisfaction with more than 8 entries per month. This trial is related to the following KPI: People reached training/awareness (PRt).

3.4.3. Validation of energy and costs reduction

In order to be able to measure energy and cost reduction, a baseline needs to be calculated which is related with the forecasting algorithms trial. Once this baseline is available, using data from the dashboard after the implementation of flexibility tests or notifications, it can be measured the energy shift and savings. The day's prices collected by the PHOENIX platform will allow to estimate the cost reductions of these activities.

If the baseline can't be properly estimated, MIWenergia will use the energy consumption just before and after the event to calculate this baseline and compare it with the one during the event. This would allow to extrapolate these values to get the available savings in cost and energy with the implementation of the flexibility tests and suggestions.

This trial is related to the following KPIs: Total target energy saving 20% (TES) and Energy cost reduction of over 20% (ECR).

3.4.4. Flexibility extraction

This trial was first performed in summer season, more exactly in M23. Other tests will be held in the winter season following the same method as for the previous events. The procedure follows the one developed by UMU.

The time interval in which the event can be carried out is indicated, this usually does not include non-working hours. Once it has been defined, to analyse within that period, the rises and falls of the energy price, forecasting is carried out by evaluating it. The next day's prices are obtained from the Day Ahead market data collected by the PHOENIX platform, which publishes, at a certain time of the current day, the real prices of next day.

Thus, when both occur at the same time (range in which the flexibility extraction and the analysis of the decreases in these prices can be carried out), the monitored HVAC devices are programmed so that their consumption is transferred to all these periods or simply to the one(s) chosen from them. In this way, flexibility from high price periods to low price periods is obtained. The precooling phase was programmed to set in low tariffs periods and to finish when the high tariff periods come.

In the following figures it can be seen the periods that were selected for testing:

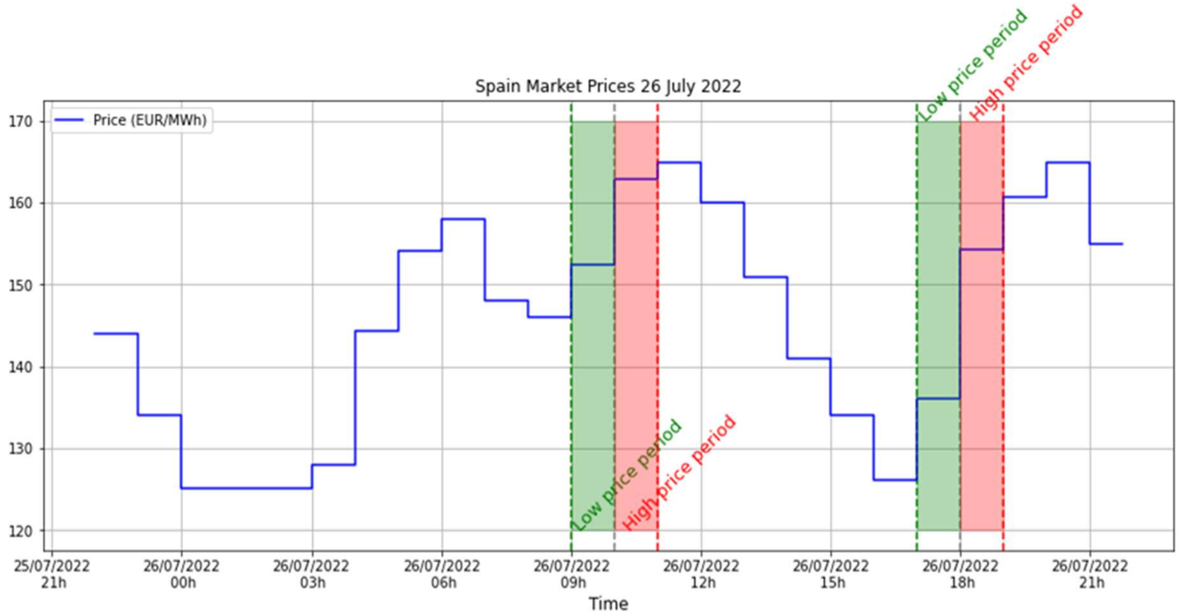


Figure 19 Periods selected for testing on July 26th

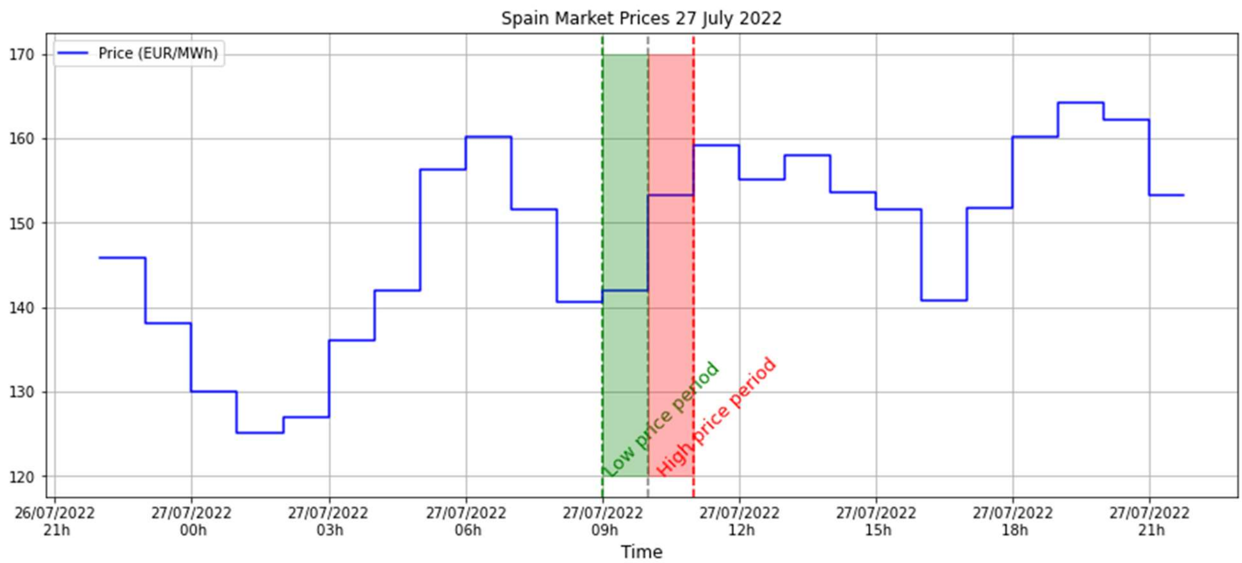


Figure 20 Periods selected for testing on July 27th

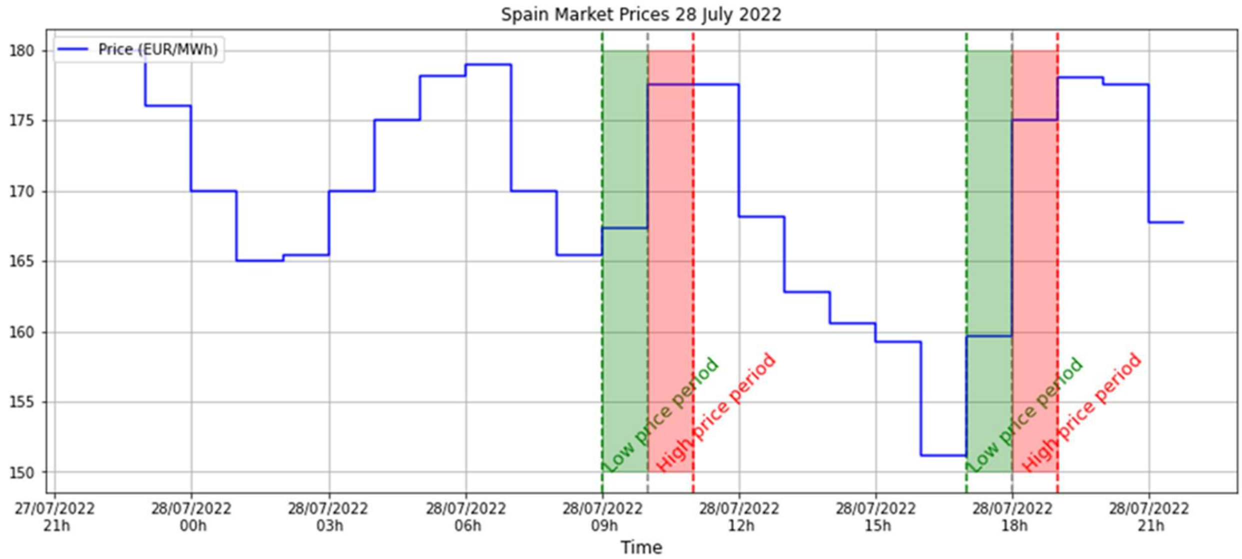


Figure 21 Periods of time selected for testing on July 28th

The tests were performed in 9 HVAC units from 7 zones in CEEIC building. Although not all tests could be launched in every device due to different reasons, in the next two figures it can be seen clearly the effect of the flexibility action when the test was positive:

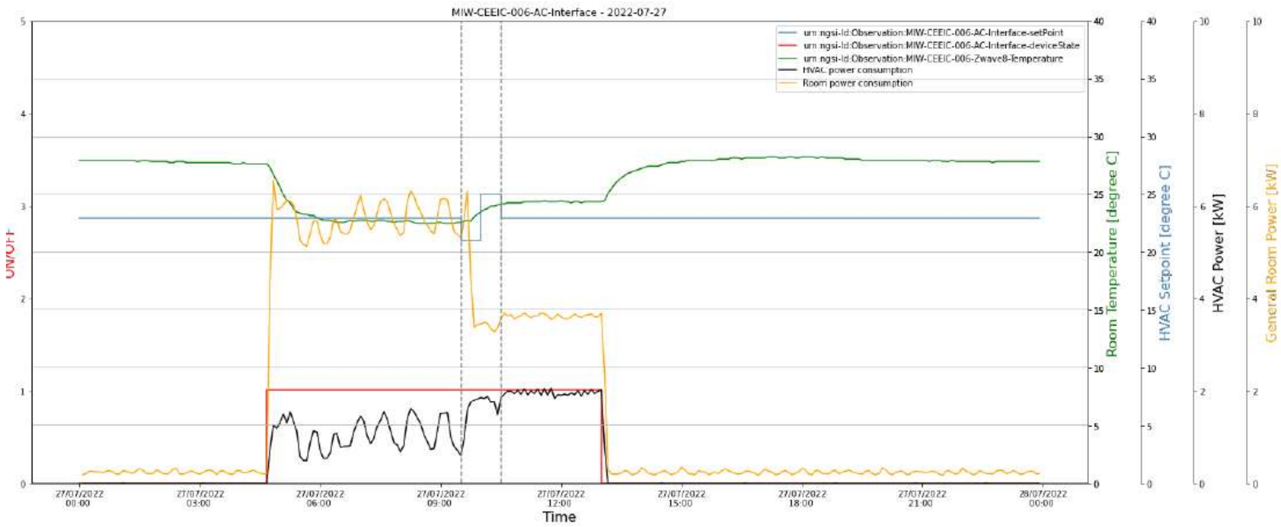


Figure 22 Flexibility test in MIW-CEEIC-006

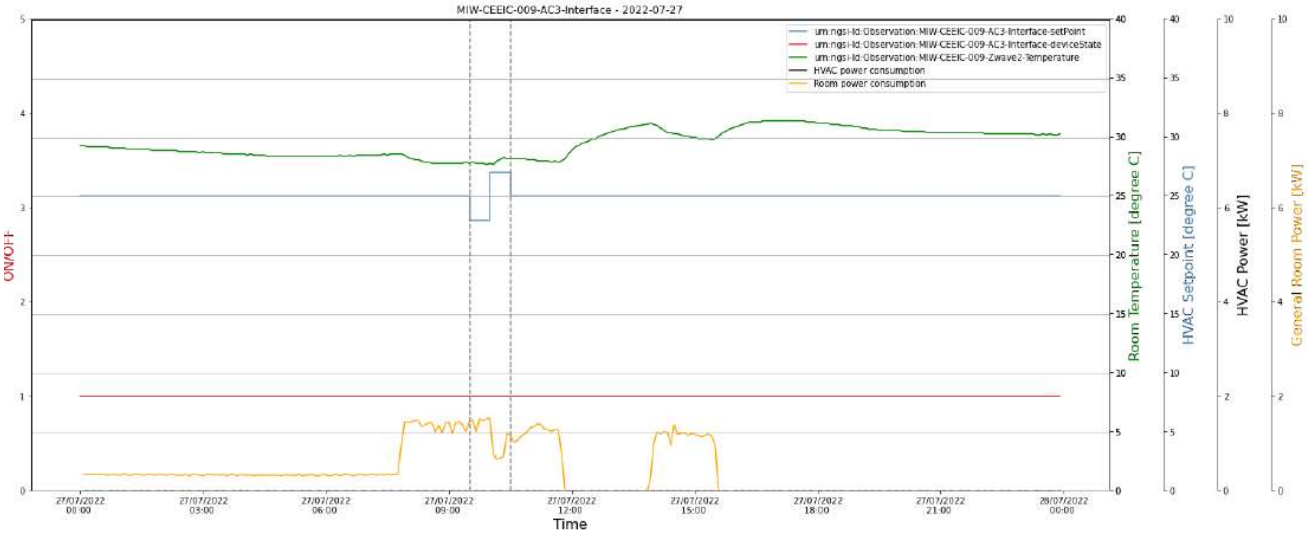


Figure 23 Flexibility test in MIW-CEEIC-009

In the first zone, it can be seen that there were other loads that affected the total consumption, for that reason, HVAC consumption was considered in order to study the results of the test. It can be observed that there was an increase in the room temperature despite the setpoint introduced in the HVAC unit, probably due to outside temperature increase, but even though the consumption during the second phase of the test was similar to the pre-cooling phase, it was lower than the average during the following hours and the costs were reduce during that half an hour.

Period	Room Temp	Setpoint	HVAC consumption kWh	Energy increase kWh	Energy price €/MWh	Cost €
9:00-9:30	22.57	25	0.768	-	141.94	0.109
9:30-10:00	23.18	23	1.46	0.692	141.94	0.207
10:00-10:30	24.05	27	1.446	-0.014	153.33	0.222
10:30-11:00	24.32	25	1.636	-	153.33	0.251

Table 4 MIW Flexibility Test – Zone 1

In the second zone, data from the HVAC consumption wasn't available but observing the total consumption, it can be seen the results of the flexibility actions: a slightly increase in the consumption during the pre-cooling phase but a visible lower consumption during the next phase compared to the one after that. Here it can be seen the effect in the room temperature.

Period	Room Temp	Setpoint	Total Consumption kWh	Energy increase kWh	Energy price €/MWh	Cost €
9:00-9:30	27.83	25	0.588	-	141.94	0.083
9:30-10:00	27.77	23	0.614	0.026	141.94	0.087
10:00-10:30	28.17	27	0.374	-0.24	153.33	0.057
10:30-11:00	28.15	25	0.503	-	153.33	0.077

Table 5 MIW Flexibility Test – Zone 2

In this last chart, where the previous conditions (temperature, consumption, etc.) were more stable than the first one, it can be seen how the flexibility test, managed to reduce consumption (25.6% reduction after only a 4.4% increase) and costs 4.7% in this period (considering equal consumption during the testing period as the consumption before and after).

This method will be used for the zones in CEEIC where the HVAC control devices is operative. For the other zones and the residential dwellings, what it is planned is to provide notification in order to implement implicit (non-automatic) DR.

This trial is related to the following KPIs: Load shifted (15% and kWh) from high tariff to low tariff and from low renewable generation to high renewable generation (LoS) and Energy cost reduction of over 20% (ECR).

Moreover, possible flexibility extraction events will be studied in order to automatically modify HVAC settings or send notifications to the end-users, in order not to shift but reduce the consumption during high price hours.

3.4.5. Forecasting algorithms (consumption)

As mentioned before, this trial is related to the validation of energy and cost reduction. Once it is fully available, MIWenergia will check the functionality of those algorithms, in two steps. The first step is observing that the data is received and store in the platform and then comparing the results of the forecasting with the real consumption. The success criterion is a deviation under 20%.

3.4.6. MIWEnergia Pilot Summary

No	Trial name	Status	Month	Description	KPIs
1	Validate successful integration of devices	Trial completed and KPI Demonstrated	M21/M23	All devices connected successfully to gateway, sending data to the platform	IoE, ISoB
2	User acceptance of smart controls	Trial in progress with preliminary KPIs	M23/M35	Collecting data concerning number of interactions with the PHOENIX dashboard Pilot occupant satisfaction collected via questionnaire	PRt
3	Validation of energy and costs reduction	To start during winter season.	M28/M30	Calculation of baseline or energy consumption before and after flexibility tests. Comparison with consumption during tests.	TES, ECR

No	Trial name	Status	Month	Description	KPIs
				Use of daily prices in the platform to calculate savings.	
4	Flexibility extraction	Summer season: completed Cooling season: to perform	M23 M28/M29	DR events is sent to device controllers or notifications for implicit DR to shift consumption from high tariff periods to medium	LoS,
5	Forecasting algorithms (consumption)	To start during winter season.	M27/M29	Check that data are received and stored in the platform and compare energy predicted with real consumption	EPM

Table 6 Summary of Spanish MIWEnergia Trials

3.5. Swedish Pilot (LTU and Skebit)

In Table 7 in Section 3.5.7 we list the trials for the Swedish pilot. Trial no. 1 is already finished. Trial no. 5 and 7 have been started. The remainder of the trials have not been started yet. We are still waiting for services provided by other partners.

3.5.1. Integration of devices

Currently LTU and Skebit have successfully completed trial no.1, integration of devices. The devices are integrated in two different ways. We installed a new equipment for integration with the legacy system, which is communicating with an LTU FIWARE platform. We then have a FIWARE to FIWARE communication between the LTU platform and the PHOENIX platform. We also installed CO_2 sensors and digital thermostats in some of the apartments. These are communicating via a Raspberry pi directly with the PHOENIX platform.

This trial is related to the KPI's EPM, ISoB and TES. Furthermore, the integration of devices has been validated. This was completed in month 24.

3.5.2. Resident's engagement

The residents' engagement trial will be carried out when the residents of the building start to get suggestions on how to optimize their energy consumption and comfort by using the PHOENIX tools, and after they have received training in how to use these tools. It is then that we will measure how often they follow the instructions and use the tools to measure their level of engagement. This trial is related to the KPI's EPM, ISoB and TES.

3.5.3. Forecasting algorithms (consumption)

The forecasting algorithm trial based on consumption will take place when we have forecasting service in place, then we will check what is received and store the forecasting data. This will then be followed by comparing forecasted and real time data to determine savings in consumption. This trial will take start in month 27. This trial is related to the KPI TES and the service of forecasting. Also to note that in the Swedish pilot the winter season is more significant in terms of savings due to the very north geographic location and extreme winter weather. There is no cooling system in the pilot building, so the energy consumption during summer is very low.

3.5.4. User acceptance of smart controls

Trial no. 5 has also been started. We already have the devices fully integrated with the PHOENIX platform, some devices via the LTU FIWARE platform and some directly to the PHOENIX platform. However the residents still don't have access to the data from them. Once the PHOENIX tools are in place and the residents have received the training in how to use them, we will perform a survey with a questionnaire to get feedback on how satisfied the residents are. There is already a plan in place to provide training to residents when the tool is available. This trial is related to the KPI's IoE, DoE, RFF, UA, PRt and CF and to control services.

There will not be any direct control from the PHOENIX system of equipment in the building. There will be recommendations given to the residents, and the building manager, and they then choose if they follow the recommendations and change set values or not.

3.5.5. Evaluation of comfort and convenience

This trial is performed to evaluate if the residents follow the recommendations provided by the platform that are related to PHOENIX non-energy services.

Like in other pilots, the comfort and convenience trial will be carried out in the Swedish pilot. This will be planned in cooperation with Ubitech and will begin in month 28. We will also perform a survey using a questionnaire with the participants who will be giving feedback if the comfort and convenience was improved after the interventions. The goal would be to evaluate if the smart suggestions approved by the residents fulfilled the targets in residents' comfort and convenience, without compromising the goals for energy and cost savings

This will also link to the next trial with the SRI calculation since the SRI tool calculates the comfort and convenience. This trial is related to the KPI's IoE, SoE, UA, NoS and CF, and services for comfort and convenience.

3.5.6. SRI increase

Further the SRI trial to check increase in SRI is being carried out in month 28. We already calculated the SRI value of the building before the intervention and also calculated the expected SRI value after the intervention. As a next step, what remains is to make a calculation of the real outcome after the intervention is made through the PHOENIX tools. This trial is related to the KPI SRL.

3.5.7. Summary of Swedish Trials

No	Trial name	Status	Month	Description	Relevant KPIs
1	Integration of devices	Finalized	24-	All devices are connected successfully to the gateway.	EPM, ISoB, TES
2	Residents' engagement	Planned	27-30	Check if the residents follow the suggestions of the dashboard.	EPM, ISoB, TES
3	Forecasting algorithms (consumption)	Planned	27-30	During this trial we will validate the load forecasting algorithms by comparing forecasting results to real data from the site.	TES
4	User acceptance of smart controls	Planned	27-30	Information on consumption and energy performance as well as enhanced controls.	IoE, SoE, RFF, UA, PRt, CF
5	User acceptance of smart controls	Trial in progress with preliminary KPIs	27-30	Devices fully integrated with PHOENIX platform and access granted to occupants of pilot sites.	IoE, SoE, RFF, UA, PRt, CF
6	Evaluation of comfort and convenience	Planned	28-30	The enhanced smart controls and information provided to occupants at the Swedish pilots will improve comfort and convenience.	IoE, SoE, UA, NoS, CF
7	SRI increase	Trial in progress with preliminary KPIs	28-30	The smartness of the buildings is measured by increasing the total SRI of the building.	SRL

Table 7 Summary of Swedish Trials

4. Smart Readiness Indicator (SRI)

4.1. SRI Framework for pilots' validation

The Smart Readiness Indicator (SRI) is of great importance in the PHOENIX project as it is used for the evaluation and validation of the interventions carried out in each of the pilots. For this purpose, a framework has been designed to obtain the SRI score for each building, which makes use of the methodology proposed by the European Commission considering different domains and impact criteria. The periodic evaluation of the SRI score in the pilot's buildings helps to study the updates in the deployment of the pilots and the services offered in each one of them in the different phases of the project, its impact on the smart readiness of buildings and its capability.

The SRI framework developed in T3.4 allows to obtain the SRI score manually using the calculation sheet proposed by the European Community, considering the devices installed, services offered and technical characteristics of the buildings as detailed in D3.3.

This has been the methodology used so far for the calculation of the SRI, obtaining the results before and after the pilot interventions shown in Table 8.

4.2. Measures to Improve SRI

The measures taken at the pilot sites were predominantly centred around integration of legacy devices in buildings rather than extensive retrofits of heating systems or other services. A number of devices were installed across the pilots to facilitate the integration, but works were generally focussed on integration and smart devices rather than on broader energy retrofits. This differs to the approach in other studies where smart readiness measures are carried out in parallel with expensive general energy retrofit measures such as boiler replacements and heating system upgrades.

Case Study	Arden			KaMa	LTU	MIWenergía		UMU
Location	Dublin, Ireland. West Europe			Thessaloniki, Greece. South Europe	Skellefteå, Sweden. North Europe	Region of Murcia, Spain. South Europe		Murcia, Spain South Europe
Building name	ARDEN-Rediscovery-Centre	ARDEN-Domestic 1	ARDEN-Domestic 2	KAMA-Building	Skellefteahus	MIW-CEEIC	MIW-Resid	UMU-Pleiades
Building typology	Non-residential	Residential	Residential	Residential	Residential	Non-residential	Residential	Non-residential
SRI score before	14%	5%	4%	12%	7%	8%	9%	13%
SRI score after	29%	37%	12%	34%	15%	32%	15%	40%
Cost of Interventions	€8,000	€5,700[4]	€3,500	€10,730	€5,600[5]	€7,028	€1,660	€13,600
Area (m2)	1,162	130	145	730	1,920	1,170	500	10,983

Table 8 SRI score of the pilot buildings

In general measures in the PHOENIX pilots consisted of lower cost investments such as the installation of gateways and communications devices. Figure 24 shows the breakdown of the effectiveness of measures implemented in the Irish Commercial Pilot. The domain for which measures have the greatest impact is for heating, which is not surprising given the weighting applied to heating. The provision of flexibility and grid interaction for heating alone contributed one third of the improvement in SRI. This consisted of making the heating system capable of

[4] The cost of interventions includes the cost of gateways, communication, software and other measures related to the integration of legacy devices. The installation of new equipment, such as the cost of installing Solar PV at Irish Domestic Pilot #2, although enabling an improvement in the SRI is not included.

[5] The cost of interventions includes the cost of gateways, communication, software and other measures related to the integration of legacy devices. The installation of new equipment, such as the EV charging system installed in the Swedish pilot, although enabling an improvement in the SRI is not included.

flexible control through grid signals (e.g. DSM). This required no hardware investment after the existing BMS was integrated with the PHOENIX platform and is a very cost-effective measure for the improvement of the SRI.

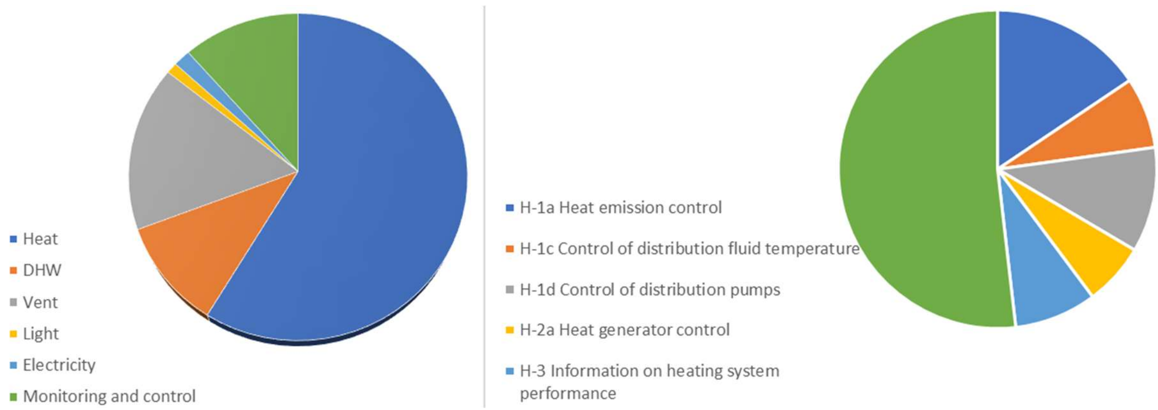


Figure 24 SRI Improvements – Irish Commercial Pilot

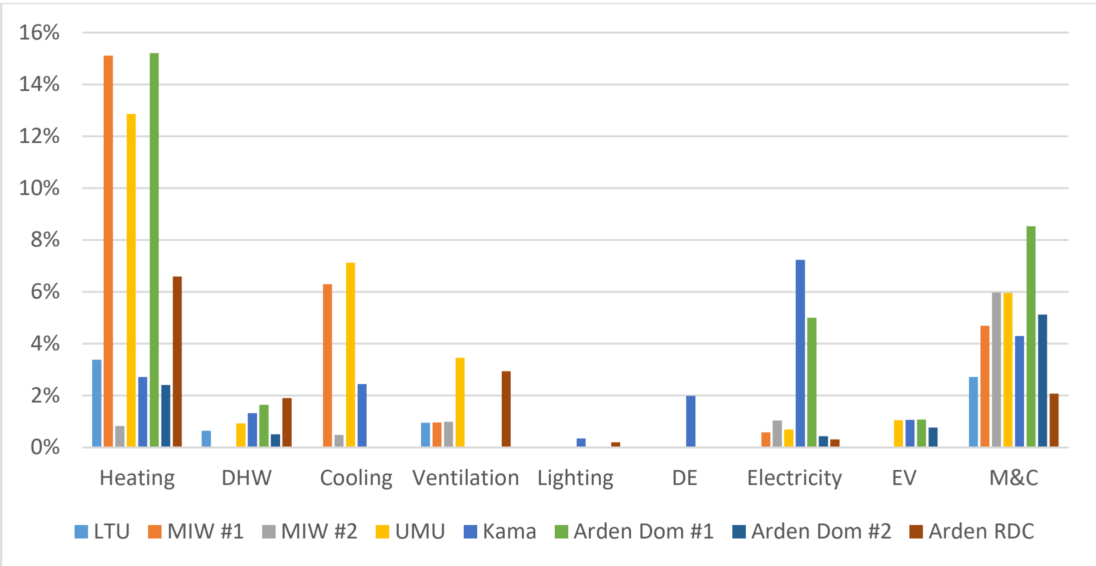


Figure 25 SRI Improvements by Domain in all the pilots

Figure 25 shows the improvement in SRI by domain for all pilots and Figure 26 shows the improvement by service group for all pilots. The domain with the largest improvement is Heating with the service group H-4 Flexibility and Grid Interaction providing the largest improvement. This improvement is delivered through integration with the PHOENIX platform and the enabling of Level 3 - Heating system capable of flexible control through grid signals (e.g. DSM). This is a very cost effective means of improving the SRI once the legacy heating system is integrated with the PHOENIX platform as no additional installation or hardware is needed on site.

The cost per m[2] of integration measures varied from €1.24/m2 at UMU to €43.85 at the Irish Domestic Pilot #1. These are relatively low upgrade costs showing that integration of legacy devices provides a cost effective means of upgrading and improving smart readiness of buildings. The costs were lower at larger buildings with pre-existing BMS as much of the infrastructure was already in place and the upgrades required mainly entailed communications and integration rather than extensive equipment upgrades. The costs do not include the costs of energy system upgrades such as the installation of solar PV at the Irish Domestic Pilot #2 or the installation of and EV charger at the Swedish pilot as the project is focused on the integration of legacy equipment. Were these costs to be included the upgrade costs would be substantially higher.

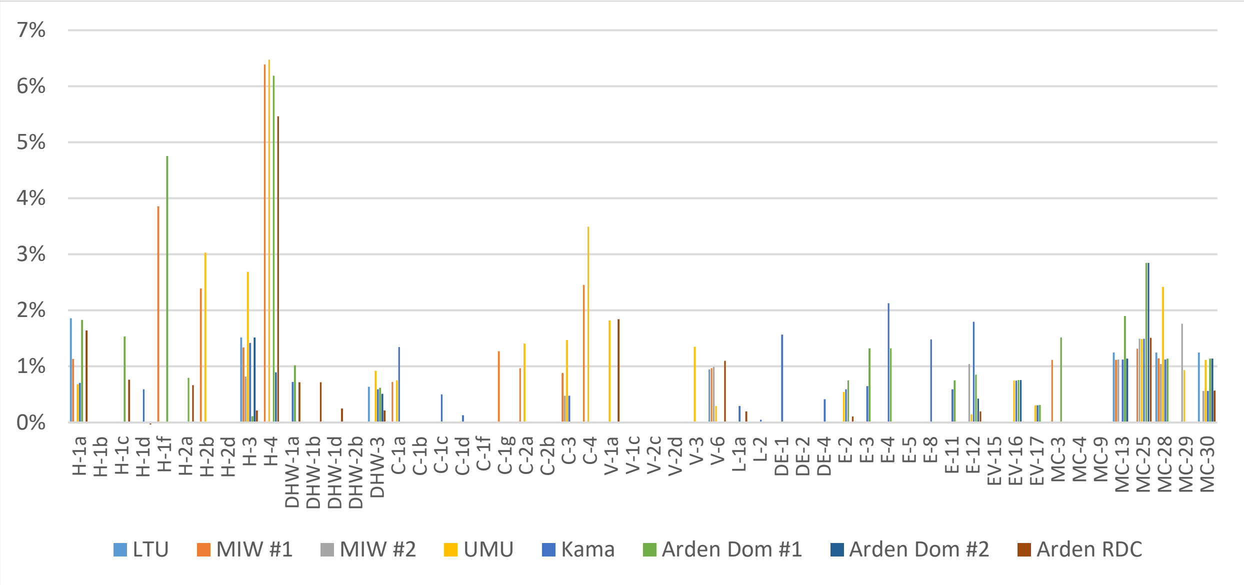


Figure 26 SRI Improvements by Domain in all the pilots

4.3. SRI automatic evaluation

As mentioned above, the SRI calculation helps to know the status of the interventions and services deployed in the pilots carried out in PHOENIX. So far, the SRI calculation framework designed in T3.4 has been very useful for the accurate calculation of the SRI score. However, an automatic assessment of the status of building interventions and services offered would be very useful during this phase of the project when the pilots are receiving the services deployed.

For this purpose, the automatic SRI aimed by T5.3 calculation engine has been developed, offering an exploratory analysis of the context information of the equipment and services in each of the buildings which, thanks to the defined semantic data model and the Triple Store database, is carried out in an effective and successful way.

First of all, the engine makes use of the SRI calculation tool offered in the SRI framework and Natural Language Processing (NLP) techniques to transform raw text data into processable data. Since this calculation sheet includes the descriptions of each smart service and functionality for each domain, a dataset is obtained for each functionality including the keywords according to the number of occurrences and, therefore, defining the semantic and linguistic requirements for each domain.

Given these results as input, the engine analyses by means of semantic queries to the Triple Store on the entities related to each building, including actuators, sensors, electric vehicles, lighting, etc. These entities have been semantically modelled and include numerous attributes that contextualise their location, purpose, operation and other characteristics. Therefore, the engine will search for all the entities of the building whose description and other attributes include the terms obtained from the NLP analysis of the calculation sheet, relating them to each domain and level of functionality. The output will be the number of devices found. In this way, knowing the importance of the terms and the number of devices related to that term, it is possible to give a partial score. By adding up the partial scores, the rate for each domain can be obtained. To these scores, weighting factors obtained from the SRI assessment tool will be applied, according to the case. Finally, considering the rate for each domain, an estimate of the SRI score is obtained.

4.4. SRI results on PHOENIX dashboard

The SRI Score results obtained through the SRI Framework designed in T3.4 can be visualised in the Building Occupants Visualisation Dashboard. This SRI framework has been integrated into the dashboard by means of a panel detailing the score for each domain and key functionality. For this, it is necessary to attach the calculation sheet with the results obtained for the pilot building. Figure 27 shows the panel with the SRI results obtained for the Pleiades building of the UMU pilot.

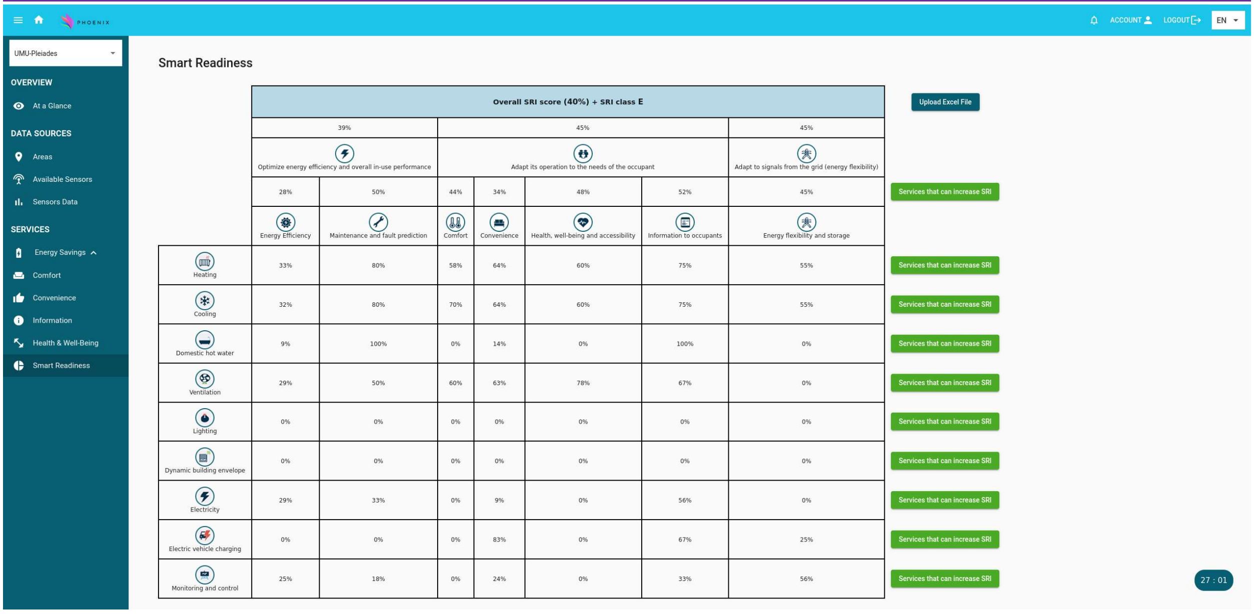


Figure 27 Dashboard panel for SRI Score

The next step is to integrate the results obtained by the automatic calculation engine, discussed in the previous section, into the dashboard panel dedicated to the Smart Readiness Indicator. Since the results of the automatic SRI engine are stored in the Real Time Context Broker after each assessment, the early availability of this information will help occupants to know their most recent estimated SRI score.

5. Conclusion and next steps

5.1. KPI summary

Figure 28 summarises the progress of pilot trials against KPIs detailed in Section 3 previously. Nearly all trials have commenced, and substantial progress has been made against the KPIs defined. Integration of Equipment (IoE) is complete in all pilot sites as is assessment of smart readiness (SRL). Energy Cost Reduction has been verified in at least one trial in KAMA and ARDEN pilots and is in progress in other trials.

KPI ID	Description	ARDEN	KAMA	Skellefteahus	MIW	UMU
BoS	Blackout support	Not Applicable	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable
CF	Comfort feedback 95%	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable	Not Applicable
CO2Sv	CO2 reduction	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable	Not Applicable
ECR	Energy cost reduction	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Not Applicable	Initial trial complete and KPI Demonstrated	Not Applicable
EPM	Energy performance measured	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs
IoE	Integration of equipment	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated
IRS	Increased residents' satisfaction	Not Applicable	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable
ISoB	Improved smartness of buildings	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs
IT	Investment triggered of 16M€ (total project)	Not Applicable	Not Applicable	Not Applicable	[dark green]	Trial Planned
LoF	Level of communication with energy providers	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable	Not Applicable
LoS	Load shifted	Initial trial complete and KPI Demonstrated	Not Applicable	Not Applicable	Initial trial complete and KPI Demonstrated	Trial completed and KPI Demonstrated
PRt	People reached training/awareness	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Trial in progress with preliminary KPIs	Trial in progress with preliminary KPIs
RFF	Revenue from flexibility and trading	Initial trial complete and KPI Demonstrated	Not Applicable	Not Applicable	Not Applicable	Not Applicable
RoIC	30-40% reduction of imbalance charges	Initial trial complete and KPI Demonstrated	Not Applicable	Not Applicable	Not Applicable	Not Applicable
RoPD	Reduction on peak demand	Initial trial complete and KPI Demonstrated	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SeS	Self-sufficiency in the order of 30-50%	Not Applicable	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable
SoE	Savings of energy from the Utility point of view	Trial Planned	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SRL	Max, mean and min Level of smart readiness	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated	Trial completed and KPI Demonstrated
TES	Total target energy saving 20 - 30%	Initial trial complete and KPI Demonstrated	Trial in progress with preliminary KPIs	Initial trial complete and KPI Demonstrated	Initial trial complete and KPI Demonstrated	Trial completed and KPI Demonstrated
UA	User acceptance of smart controls & DR	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable	Trial in progress with preliminary KPIs
UoEV	Usage of EV charging point of over 10%	Not Applicable	Trial in progress with preliminary KPIs	Not Applicable	Not Applicable	Not Applicable

Trial completed and KPI Demonstrated
Initial trial complete and KPI Demonstrated
Trial in progress with preliminary KPIs
Trial Planned
Not Applicable

Figure 28 Summary of KPIs

A number of KPIs around User Acceptance (UA) People reached training/awareness (PrT), Comfort feedback (CF) and Improved smartness of buildings (ISoB) will necessarily be demonstrated in the latter stages of the project. Other KPIs are in the process of being demonstrated and will be achieved as the trials are rolled out in the pilot sites. Total target energy saving 20 - 30% (TES) is an important overarching KPI of the project and applies to all sites; this KPI has been demonstrated in certain trials and is in the process of being demonstrated for other relevant trials.

5.2. Lessons Learned

Device Integration

A major focus of this project and the effort expended has been in the integration of legacy devices. While this has been a central focus of the project from the start, there have been difficulties with integration across all pilot sites.

Reliability & User Acceptance

There is a reticence amongst a number of pilot sites about acceptance of control of services in their building via third party platforms including all the Irish pilot sites. Indeed, initial trials in the Irish Commercial pilot accidently switched off all sources of heating for DHW during initial trials which left the building without hot water and undermined confidence in the project and the trials. Overcoming this required carefully monitored trials with continuous engagement with the pilot sites to ensure that comfort is not compromised and that the sites are happy with the project and the smart controls. This process required prolonged engagement with sites during the initial trials.

External Data Integration

The Entsoe platform doesn't report Day Ahead Market or CO_2 data for Ireland meaning that that an alternative external data source had to be integrated with the PHOENIX platform to enable the provision of flexibility services. The Irish Single Electricity Market SEMO platform reports DAM prices for the period 23:00 to 23:00 (UTC) the following day each day. This is likely due to the fact that all electricity markets across Europe are settled simultaneously and Ireland is one hour behind CET. This required a separate integration of the Irish SEMP DAM with the PHOENIX platform and adaptation of the Flexibility Engine service for the new data format. This shows that there may be unforeseen integration and data availability and compatibility issues with integration of the PHOENIX platform, and platforms in general, with legacy devices and with external data sources.

5.3. Next Steps

The next steps are to progress the further deployment of services to the pilots and the finalisation of trials and demonstration of KPIs. Figure 28 shows the progress towards demonstration of KPIs and while significant progress has been made more remains to be done. The focus will be on completion of the defined trials in each of the pilots. In some cases trials were delayed due to the seasonality of heating demands such as for evaluation of flexibility on heating supply validation of cost benefits in the Irish trials. As we enter the heating season, these trials will be progressed and executed.

Delays in integration, platform development and the delivery of services have delayed progress in trials and the attainment of KPIs. These problems have been overcome and the project is on track to complete all trials and deliver on all KPIs as planned.