WP5 – Cost-effective and User-Friendly Services for Building Users and Occupants

Document Version:

D5.2 Refinements in services for building's occupants - Initial Version

1.0

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Abstract:

This document describes the actions performed after the submission of D5.1 in the context of the services included in WP5. After the integration with the platform's core components, now the services have access to real data and some of them are almost operational. Given the current state of the services, a first version of the service test ecosystem has been introduced.

Keywords:

Dashboard, Non-Energy Services, Energy-Services, SRI, EPC, Predictive Maintenance

Revision History

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

Revision	Date	Description	Author (Organization)
0.1	21/02/2022	ToC Draft	Alfredo Quesada (OdinS)
0.2	28/02/2022	Comfort, Convenience and Wellbeing related services	Kostas Tsatsakis (S5)
0.3	04/03/2022	User Information and Dashboard, Integration, testing and refinement framework	Dimitra Georgakaki (Ubitech)
0.5	12/03/2022	Testing framework	Dimitra Georgakaki (Ubitech)
0.6	14/03/2022	Predictive Maintenance and automatic SRI calculation and EPC evaluation	Alfonso Ramallo (UMU)
0.7	18/03/2022	Minor revisions	Dimitra Georgakaki (Ubitech) Alfredo Quesada (OdinS)
0.8	24/03/2022	Internal Review	Ioanna Leotsakou (MERIT) Saguna (LTU)
1.0	29/03/2022	Final Review	Alfredo Quesada (OdinS)

Executive Summary

This document is the second part of a set of deliverables that deal with non-grid services.

After introducing (in D5.1) the goals that are expected to be achieved by the services of WP5, the present deliverable introduces the first actual steps towards the connection between services/users and pilots/devices.

The entry point of this WP is the Dashboard, which is now connected to the PHOENIX Real-Time Data Broker component and the PHOENIX Data Repository component.

Other services will run in the background and will update specific entities of the Real-Time Data Broker in a synchronous or asynchronous way which will store the results of their calculations.

After reaching this point, the services must not only be developed, but also deployed and tested. To that end, this document is the first to introduce the methodology that the service developers will follow to define their tests, which will be later executed to refine the algorithms.

Disclaimer

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Acronyms

Abbreviation	Description
DoA	Description of Actions
DSS	Decision Support System
EPC	Energy Performance Certificate
ESCO	Energy Service Company
HVAC	Heating Ventilation Air Conditioning
IAQ	Indoor Air Quality
KPI	Key Performance Indicator
S&P	Security and Privacy
SRI	Smart Readiness Indicator
UI	User Interface

1 Introduction

1.1 Scope of the document

This document is the second part of a set of deliverables that describes the development, integration, deployment and testing of energy (non-grid) and non-energy services in the PHOENIX project.

At this stage of the project, these services have a preliminary working version and some of them are actually available, with some of their features ready to be tested.

In addition, the services have direct access to real information as most of the devices have been deployed in the pilots, providing both real-time and historical data.

1.2 Relevance to other deliverables

This deliverable is related to the rest of the set, namely Deliverables 5.1, 5.3 and 5.4.

This deliverable is also connected to D2.3 *"Technical requirements and human centric architecture specifications"* where the main architecture of the project and the different views including the services and their components are listed.

This deliverable is also connected to D3.2 "*Technical upgrades and integration mechanism for legacy equipment – Intermediate version*" as the security features used by the services to get access to the information have been introduced in D3.2, an integration-focused Deliverable. In this matter, the documentation required to properly use the S&P framework to access the data is described in D4.2 "*PHOENIX Smartness Hub implementation – Intermediate Version*".

This deliverable is also connected to D6.2 "*Refinements in services for energy utilities and the grid - Initial Version*" in the integration and testing tasks as T5.4 and T6.4 might share some contents depending on how the services are going to be deployed and tested. Moreover, services of WP6 will also be integrated in the Dashboard.

This deliverable is also relevant to D7.2 "*Initial Pilots Deployment, Operation and Validation*" as D7.2 includes the list of devices of the pilots that can be used by service developers.

1.3 Structure of the document

This document is divided in four main sections in addition to this introduction, each one of them linked to one task of WP5. Section 2 describes the current status of *Comfort, Convenience and Wellbeing* related services. Section 3 describes the current status of Predictive Maintenance and automatic SRI calculation and EPC evaluation. Section 4 describes the current status of User Information and Dashboard. Section 5 introduces the integration and testing phases for the services of the WP, or at least a preliminary approach indicating some of the tools and strategies that will be available for service developers when it comes to deploy and test their services.

2 Comfort, Convenience and Wellbeing related services

2.1 Introduction

As stated in the DoA, the scope of the project reflected in the work of T5.2 is to design value added non-energy services for building occupants as also promoted by the Smart Readiness Indicator specifications. The role of the associated service bundle is to first enable identification of poor indoor conditions in buildings that may cause comfort or health issues to the building occupants. Furthermore, the component incorporates smart services that will enable either automated control of the building devices to ensure comfort, health and wellbeing conditions, or context-based personalized notifications and messages related to the comfort and wellbeing conditions in premises (while keeping the energy usage as low as possible to meet the requirements).

In order to properly design the PHOENIX non-energy services software bundle, some preliminary steps were considered as reported in the 1st version of the deliverable (D5.1):

- A review of the literature in the field of comfort, convenience and health in building environments also considering the SRI regulation about the provision of non-energy services.
- A review of project requirements with focus on social related requirements' analysis as performed in D2.2. Through this analysis, individually defined factors are extracted to denote the user-driven weighting of importance of the opportunity costs for rescheduling or postponing certain loads' use.

Then, the design of the software application took place in D5.1, highlighting the key functionalities to be incorporated in the solution at the development phase. In this version of the document, the 1st version of the *Comfort, Convenience and Wellbeing Engine* is available, incorporating the initial list of functionalities defined for the respective service. We have to point out that during this alpha testing version, special focus was delivered on the incorporation of the analytics (knowledge base) results at the business logic of the *Comfort, Convenience and Wellbeing Engine*.

2.2 Alpha version of Comfort, Convenience and Wellbeing Engine

In this section, the development activities for the alpha version of the *Comfort, Convenience and Wellbeing Engine* are reported. As stated in D5.1, there are 3 different core features that enable the functionality of the engine, namely ***Comfort, Health and Wellbeing Interface Layer***, ***Comfort, Health and Wellbeing Notification Engine*** and ***Comfort, Health and Wellbeing Automation Engine***.

2.2.1 Comfort, Health and Wellbeing Interface Layer

The role of this module is to act as the wrapper of the application in order to ensure information exchange with external components (more details are provided in the next section). The module is also responsible for the calculation of the non-energy related KPIs defined in the project (through the *Comfort, Health and Wellbeing Level Assessment* module as specified in D5.1):

- Thermal comfort: current comfort status and the average thermal comfort status for the last 10 days also considering data availability.
- Visual comfort: current comfort status and the average visual comfort status for the last 10 days also considering data availability (luminance level).
- IAQ status: current IAQ status and the average health status level considering the specifications for each metric as reported in state-of-the-art analysis.
- Automation level: considering the number of automated and manual actions triggered over the controllable devices in order to evaluate the automation level of the building.

By taking into account the data streams from building contextual conditions as well as the results of the analytics engines, sample statistics are performed over the data in order to extract the aforementioned KPIs.

2.2.2 Comfort, Health and Wellbeing Notification Engine

The role of this DSS module is to correlate building contextual conditions along with the extracted comfort profiles and user settings in order to generate the relevant notifications associated with the indoor conditions in premises. The design specifications were reported in D5.1 and in this section the implementation of the alpha version of the recommendation engine is reported.

More specifically, a rule-based engine has been implemented that takes into account dynamic and static configuration parameters in order to trigger the relevant recommendations to the users. As reported briefly in D5.1, the list of parameters incorporated in the rule-based engine is:

- Users' configuration profiles taking into account static characteristics of the users (age range, location etc.).
- Users' contextual conditions: environmental conditions, comfort profiling data.
- Recommendations' trigger points: recommendation messages, acceptance level, etc.

Overall, the main focus in the project is about the semantic rule annotation of the aforementioned model parameters towards triggering best fitted recommendations (defined following consultation with the demo partners) to the users based on contextual and operational conditions (taking also into account the business priorities of the users participating in the project).

2.2.3 Comfort, Health and Wellbeing Automation Engine

The role of this DSS module is to correlate building contextual conditions along with the extracted comfort profiles and user settings in order to automatize the operation of controllable devices (focus on HVAC, lights etc.) on the way to ensure the establishment of a comfortable, healthy and well-conditioned environment. The design specifications were reported in D5.1 and in this section the implementation of the alpha version of the automation engine is reported.

More specifically, and similar to the recommendation engine presented above, specific input parameters are incorporated in the rule-based engine in order to trigger the relevant control actions to the different controllable devices of the project (mainly HVAC but also lighting). Again, the input parameters incorporated in the automation engine are:

- Users' configuration profiles taking into account static characteristics of the users (user norms, business priorities).
- Users' contextual conditions: environmental conditions, device control status, comfort profiling data as well as occupancy related information.

Again, the main focus in the project is about the definition of the appropriate rules that need to be applied in order to ensure the implementation of user-friendly and non-intrusive control actions. The intrusiveness of the users is a core parameter that needs to be considered when applying control actions over building devices.

In this section, details about the functionality of the application are provided. In the following section the description of the relevant integration activities with the rest of the system components is provided while in section 5 the technical details are provided.

2.3 Comfort, Health and Wellbeing Engine Integration Activities

As stated in section 2.1 and in D5.1, the main focus in this alpha version is the integration with other PHOENIX components. The interface layer module is responsible for ensuring the integration with external systems in order to retrieve data from the building environment (as specified in D2.3 and technical specifications definition) and the results of user analytics as specified in WP4.

At first, integration with the PHOENIX Real-Time Data Broker is considered. The detailed specifications for this integration have been reported in D3.2. In this section, a review of the methods requested from the *Comfort, Health and Wellbeing Engine* is provided, namely:

- Access to contextual/environmental information: information about temperature, humidity, luminance and CO_2 is available from the different observation points of the project.
- Access to operational settings of controllable devices: information about the operational status of the different smart devices is also available through the real time API of the project.

The same approach is also applied for accessing the PHOENIX Platform Data Repository. Access to the long-term repository of the project is ensured via the respective services (history-temporal) exposed by the PHOENIX Platform Data Repository component.

On the other hand, the results of user-centric analytics engine are further retrieved for further exploitation. The relevant wrappers have been developed to ensure accessibility over the data about occupancy and comfort profiling. More specifically, considering the functionality of the user profiling component as specified in D4.1 and D4.2, we have analytics' results about:

- Occupancy Scheduling: providing information about the level of occupancy at a specific zone, taking into account time related parameters.
- Comfort Profiling: providing information about the comfort boundaries of the users under different environmental conditions: temperature, humidity, luminance etc.

As stated in D2.3, integration with the business layer of the PHOENIX project is considered. More specifically, interfaces are exposed to the PHOENIX building occupants' application in order to enable (a) retrieval of notifications and (b) KPI values related to *Comfort, Health and Wellbeing* services.

On the other hand, business settings, as provided by the building occupants via the PHOENIX building occupants' application, are accessible from the *Comfort, Health and Wellbeing Engine* for further analysis. More specifically, information about business control priorities (i.e. comfort preservation), operational schedules and feedback on control actions, are available.

We presented above the list of external interfaces considered for the development of the *Comfort, Health and Wellbeing Engine*. The technical integration has been performed and thus the next step is the functional testing and validation of the integration. This activity will be performed in the following months and the results will be documented in D5.3.

2.4 Comfort, Health and Wellbeing Engine – Demonstration Specifications

As stated in the 1st version of the deliverable, while the *Comfort, Health and Wellbeing Engine* is modular enough to support a fully flexible implementation, pilot-site specificities set constrains at the demonstration activities. The early feedback from the demo partners was presented in the 1st version, while in this 2nd version of the document, an update of the pilot specificities is reported taking into account the most recent installation activities performed at the demo sites (as well as the enrolment of the actual users in demonstration activities of the project).

More specifically:

- At the Spanish demo site (MIWenergia pilot), the main objective is related to the occupants' **wellbeing and health**. **Sensors measuring temperature, humidity and air quality (CO_2 level) have been deployed in all the premises of this pilot.** These sensors will provide information and would help to identify poor indoor conditions. In the residential site, there is no automation expected thus only **informative notifications** will be received. Considering the synthesis of the occupants in place (non tech familiar) the messages should be mainly informative (occupants getting knowledge about their comfort conditions) rather than normative. In the office building some **automation** could be implemented in the **HVAC system** avoiding excessive consumption while preserving the **comfort boundaries**.
- At the Greek demo site, messages in the form of recommendations and suggestions to the residents should be provided. Considering the building typology and the occupants' characteristics, the focus should be on establishing a comfortable (focus on thermal comfort) and healthy environment.
- At the Irish demo site, the main differentiation from the previous version is the incorporation of IAQ monitoring towards the provision of health services. While in most of the cases informative recommendations are the preferable way for interacting with the

non tech users, there is a limited number of residential users where the provision of fully automation services should be considered.

- At the Swedish demo site, the incorporation of some controllability of the HVAC devices has been ensured and thus some level of automation will be tested. In addition, the recommendation engine will be demonstrated where the focus is at the provision of a service for elderly people.

The latest feedback from the demo partners is also considered in order to define the demonstration activities specifications towards the delivery of the beta version of the application which will follow in D5.3.

3 Predictive Maintenance and automatic SRI calculation and EPC evaluation

3.1 Introduction

Task 5.3 contains the efforts that have been performed on the development of services particularly designed for the good operation of the building and other building management activities. The three services that have been considered have been described in D5.1, and their requirements and broad descriptions have been defined. The three services are:

- Predictive maintenance. The new arrival of smart services is an opportunity to make the building self-diagnose, while the different maintenance activities are optimised. For the PHOENIX solutions a great deal of equipment has been monitored to make possible the evaluation of predictive maintenance services. For a state of the art analysis of predictive maintenance one can look at Section 3.2 of D5.1. The developments and refinements performed on the definition of these services will be shown in this deliverable.
- Automatic SRI evaluation. As in the previous case, a revision of the state of the art on this topic can be found in D5.1. The SRI is a rather new assessment, and there has been little development on how to perform this assessment automatically. However, the requirements and the contextualisation towards this development have been shown in D5.1. In this document we show how the design of the services of the PHOENIX platform are per se a contribution towards the automatic evaluation of the SRI.
- EPC evaluation. Although the automatic evaluation of the Energy Performance Certificate has not achieved technological maturity, it is true that there are scientific developments that based on inverse modelling manage to obtain heat transfer coefficients

thus leading to the parameters of the EPC. In this deliverable we will explain the refinements that were done towards the achievement of obtaining the EPCs automatically using the PHOENIX solution.

3.2 Alpha version of the engine for Predictive maintenance, automatic SRI calculation and EPC evaluation

The alpha version of the engine covering these three families contains services that will serve as evaluation trials of the engine itself.

3.2.1 Predictive maintenance

The predictive maintenance service will include an evaluation of the drifting of variables that represent the operation of devices. In this sense, there are several machines which report operational parameters. For this specific case, the predictive maintenance of the generation of electricity on the photovoltaic installation will be executed.

3.2.2 Automatic SRI calculation

For the development of the SRI automatic evaluation, the consortium has developed a series of approaches that facilitate the automation of the process to obtain the SRI. The SRI represents the capabilities of the building to provide smart services, yet this can be achieved in two ways. First, by connecting certain building devices to the internet and communicating with the platform, a certain SRI level can be achieved. Second, by providing data from the devices and using on a certain way the capacities of actuation (thanks to the actuators), SRI levels can also be obtained. Therefore, there are two steps required in order to increase the SRI levels; one is the incorporation of hardware, and the other is the incorporation of software. This has been represented in Figure 1.

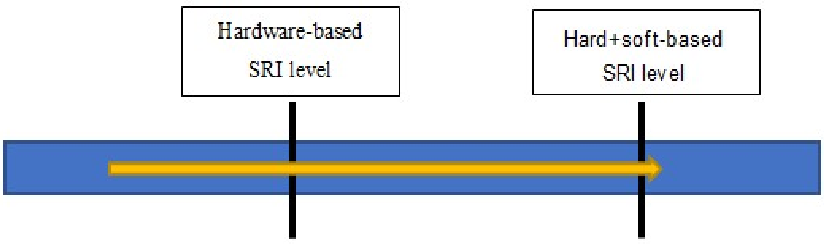


Figure 1 – Increasing the SRI with hardware and software

Due to the importance of the SRI in this project, a dedicated conceptual definition of the SRI automatic evaluation services has been developed and it is shown in Figure 2. This Figure illustrates how the PHOENIX solution will explore the content of entities on the Context Broker and the triple store to identify the devices that are connected to the PHOENIX platform, thus contributing to the smartness of the building (i.e., contributing to the SRI). As shown in the diagram, in the same way as the system evaluated the hardware with the context broker, the user can manually introduce the excel file which provides the information about the SRI (with the standard SRI evaluation file). Using this file, it will be possible to complement the information that has been automatically obtained from the context broker and the triple store.

The second important part of the SRI automatic evaluation service is that the service itself can suggest the implementation of certain services that can help increasing the SRI. The suggestions are based on software integrations, and their results are easily identified on the Context Broker. This is because the results of these services are created within the PHOENIX platform and with a known and recognised by the SRI assessment engine format.

The dashboard has been equipped with a dedicated screen to integrate the features that are relevant to the SRI. Within this screen, a visualisation of the SRI matrix will be included. Also, a dialog box for the user to upload the excel file with SRI information will be available. Finally, there will be dynamic buttons that allow the user to explore the services that are implemented and those that they could be implemented to rise the SRI. More about this visual interface to the SRI features of PHOENIX can be seen in section 4.

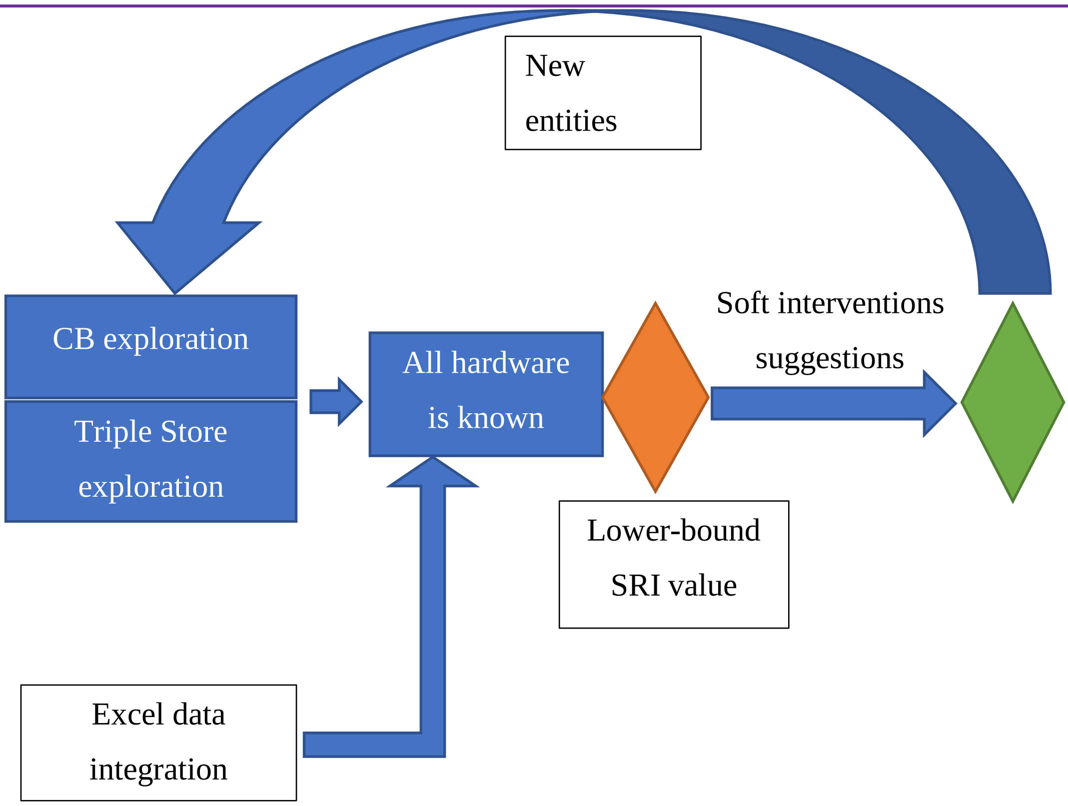


Figure 2 – Diagram of Automatic SRI Evaluation and improvement

3.2.3 Automatic EPC evaluation

Within the framework of the PHOENIX platform a set of algorithms has been implemented to facilitate the calculation of the EPC. For this, the inverse modelling approach has been chosen, as most of the pilots in the project have temperature time series and consumption of conditioning systems. Also, the availability of environmental variables such as external temperatures and solar irradiance integrated on the context broker for all pilots facilitate this.

The data obtained on the PoC and now part of the UMU pilot is considered adequate to perform this kind of assessments. Figure 3 presents the time series that will be used for the characterisation of the heat transfer of the room. In this preliminary test we have seen that the thermodynamic behaviour of the room follows either a first order or a second order dynamic behaviour, which means that the characterisation can be done with a Lumped Parameter Model, and therefore with the methodology of inverse modelling.

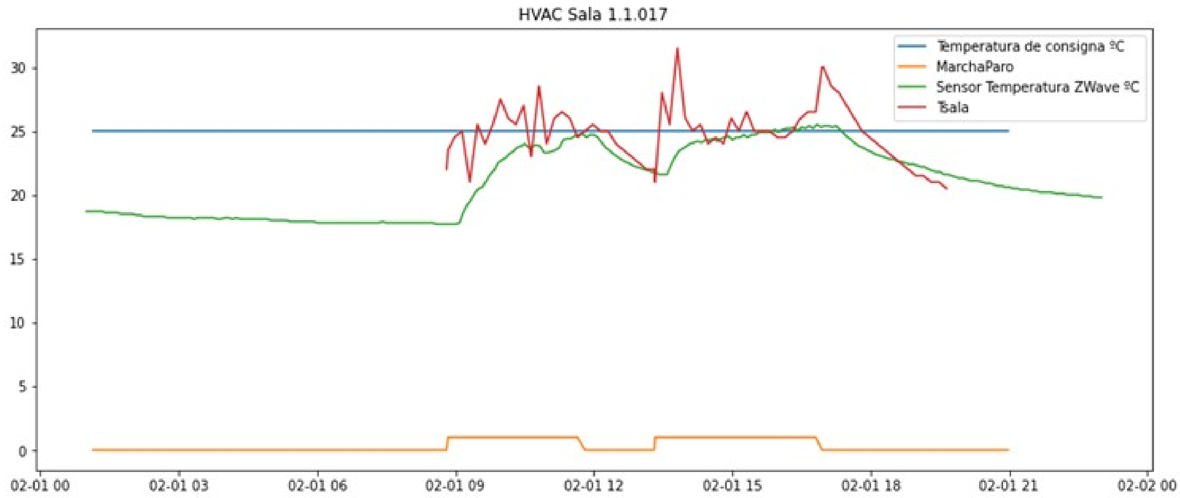


Figure 3 – Representation of the temperature of room 17 of the PLEIADES pilot. It can be seen that the sensors integrated with Z-Wave provide a reliable temperature series in addition to the operation information of the heating

The time series that have been selected for the thermodynamic characterisation of the spaces will then allow obtaining the parameters of conductivity and capacitance of the Lumped Parameter Model as shown in Figure 4. Once the optimisation algorithm has found the values for R1, Rb and R2, the heat transfer coefficient could be obtained as the inverse of the equivalent resistor of the association of resistances. The values of the capacitors will then serve to obtain the time constants of the zone, which is directly related to the time needed for the external temperature to cool down the place or for the internal heating to heat up the space.

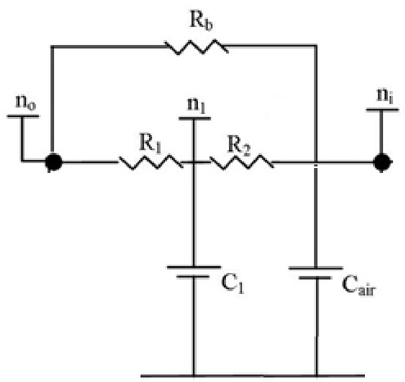


Figure 4 – Second order lumped parameter model to represent the thermodynamics of the zones

3.3 Integration activities of the Predictive maintenance, automatic SRI and EPC evaluation

The alpha version of the services for maintenance and building assessment has served to test the integration of the component in the PHOENIX solution. In that sense, the services created under this task are highly heterogeneous. The services for predictive maintenance and those for EPC automatic assessment are deeply dependent on time series data that is stored on the historic data repository of the context broker. However, the information on the context broker relative to the entities that are connected to the platform in addition to contextual information of the entities and their relationships. For a more detail explanation, the following sections show connections that had to be created for the services of this task to function in the PHOENIX platform.

3.3.1 Predictive maintenance

For the predictive maintenance service, there were a series of necessary connections which will be used on the provision of the services of predictive maintenance:

- Produced power of the renewable energy systems (solar PV, and solar thermal).
- Status and power delivered by conditioning systems.
- Status and operation of ventilation systems.
- Contextual information of systems and devices' location.
- Contextual information of systems and devices' equipment connection.

3.3.2 Automatic SRI calculation.

For the service of SRI evaluation and SRI increasing advice the connections with other elements are as it follows:

- Connection to context broker to identify devices that affect SRI levels.
- Connection to context broker to identify relationships between devices.
- Connection to context broker to identify entities results of other services and algorithms that increase the SRI (visualisation of renewable production, evaluation of performance, etc.).
- Connection to dashboard to integrate manual input about SRI levels via Excel file.

3.3.3 Automatic EPC calculation

The automatic EPC calculation requires a mix of connections with a variety of components as it requires information about the building and its areas that are entities existing on the context broker, as well as time series from the sensors that can be found on the historical databases. An explicit list of these connections is:

- NSGI-LD entities of buildings.
- NSGI-LD entity of zones.
- Contextual information of entities on the context broker.
- Time series data of temperatures and consumptions of the zones and the buildings.

3.4 Demonstrations specifications of the Predictive Maintenance, Automatic SRI calculation and EPC evaluation

The three components of this task have been envisioned to be tested within the pilot demonstrations. In that sense different approaches have been taken for the different pilots and the different services. The following sections include a description of the services on the different pilots.

3.4.1 Predictive maintenance

With respect to the predictive maintenance there will be evaluation of the services on the pilots with PV generation. In this case, the maintenance of the production of the panels will be assessed by checking the production of them and comparing it with benchmarking productions including data such as weather data. The KaMa pilot has PV panels connected to inverters and to a battery bank. Both the production of the PV panels and the energy flows of the batteries will serve to check the maintenance algorithms of this service. Within the ARDEN pilot there is also PV production that will be monitored and checked against benchmarks, to identify the good functioning, but also a CHM microgeneration plan will be monitored to identify potential failures. The UMU pilot has its PV plants and his Solar thermal plant connected to the PHOENIX platform, the predictive maintenance algorithms will be used to control the efficiency of these two systems and with it, identify the operation.

3.4.2 Automatic SRI calculation

With respect to the SRI calculation, all pilot partners have had a formal assessment of their current situation. In addition, they have also filled the excel file that provides the information about the SRI. In this respect, the SRI automatic evaluation framework will be capable of evaluating the entities that appear on the context broker together with the information that has been introduced manually and has information about the SRI level. Within this aspect, all pilots will offer the possibility of checking the automatic evaluation with the manually introduced data, yet some pilots will have more domains covered than others. It is worth reflecting that UMU has electric vehicles, KaMa has electric storage on batteries, ARDEN has dynamic envelope and that LTU has FIWARE entities on a dedicated BMS.

3.4.3 Automatic EPC calculation

With respect to this service, the PHOENIX solution will use the information about the pilots regarding buildings and zones characteristics, while the data series will be taken into consideration too. All pilot partners have been asked to fill templates (as in Figure 5) in which they include the contextual information of the buildings, of the zones, and of the devices that are either included in the zone or 'serve' the zone (such as heating). With this it is possible to obtain the necessary information of the areas that provide with the heat transfer coefficient. This, in addition to the EPC certificates that will be uploaded in the platform will allow us to evaluate the automatic algorithms that inform about the efficiency of the buildings.

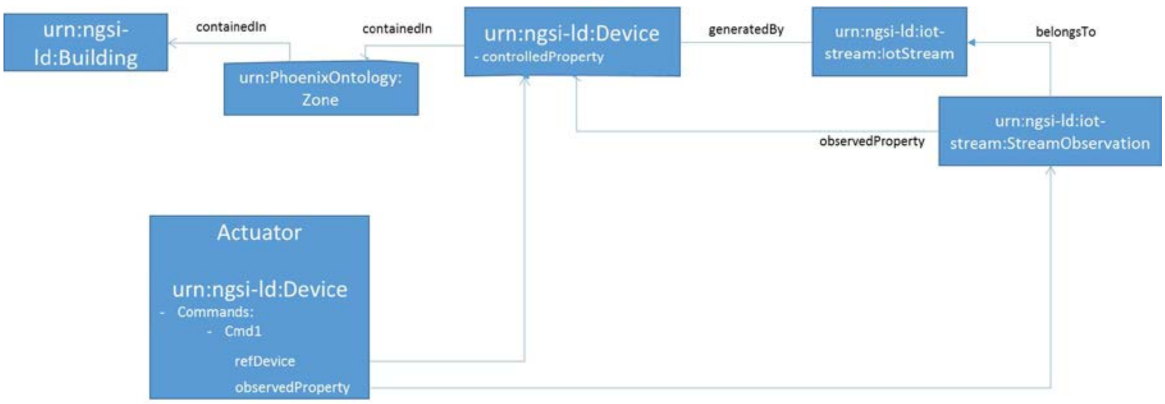


Figure 5 – Data model on cascade for building zone and device

4 User Information and Dashboard

The human-building experience and interaction (HBI), as described in the objectives of WP5, are delivered through an intuitive and informative end-user dashboard. The end user in the PHOENIX project can be either the building occupant or the building manager, the latter simulating the role of ESCO or Aggregator (this will be described in D6.2).

The Building Occupants Visualization Dashboard (as described in D2.3) is deployed in a secured Kubernetes cluster environment giving external access to the users via the link https://dashboard-eu-phoenix.euprojects.net/. Every page presented below is not just a mock-up page like described in D5.1, now it represents a real functional page with live data coming from the PHOENIX Real-Time Data Broker or the PHOENIX Data Repository (historic data). The Home Page provides some general information about the project, the respective promo video and the ability for user registration and login.

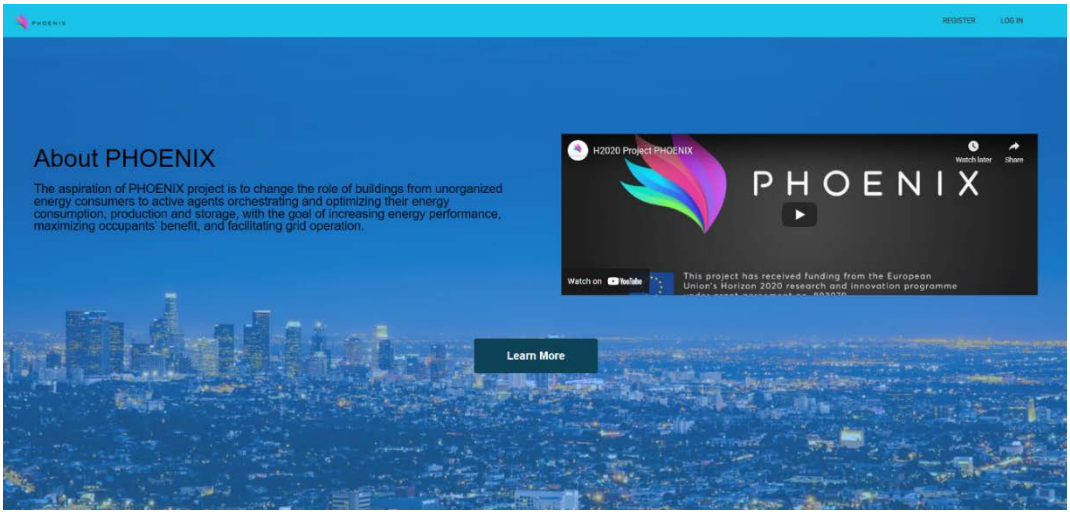
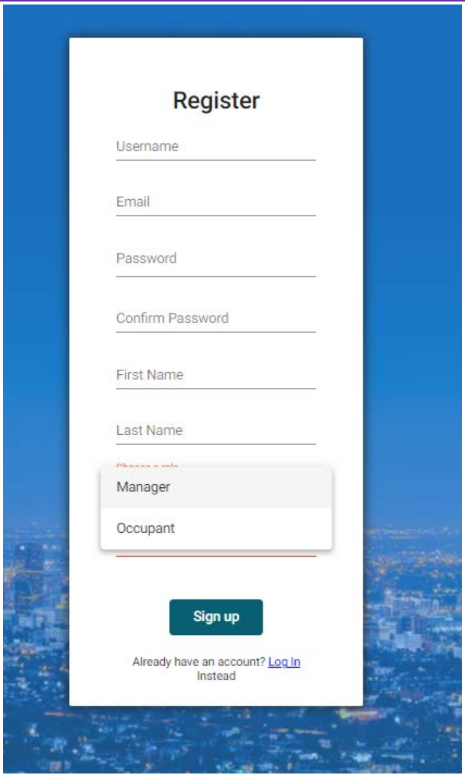


Figure 6 – The Home Page of the Building Occupants Visualization Dashboard

A new user can register in the dashboard by completing the respective form and submitting it.



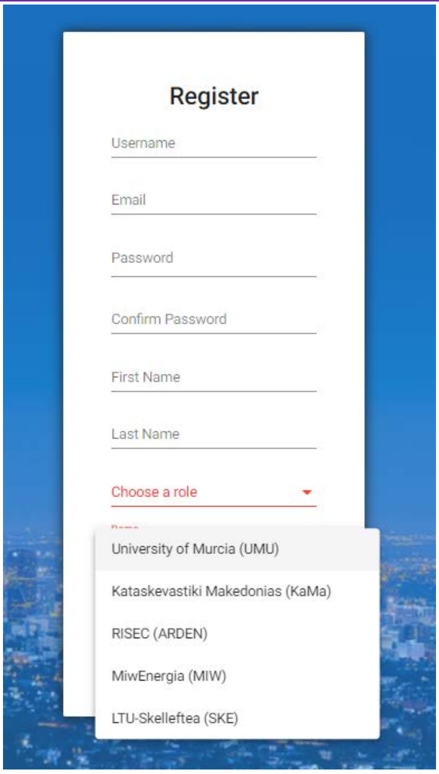


Figure 7 – Selection of *Role* (a) and *Demo Site* (b) in the registration form

Username and email must be unique for each new user and a strong password is needed for the authentication process. If the user chooses the role of the occupant, then (s)he will be redirected to the respective content whereas if (s)he chooses the role manager, different content will be shared with him (or her). In order to increase security for the manager role, Ubitech can provide predefined usernames and passwords upon request so that no other user can try to register with the role of the manager unless (s)he is actually one.

Regarding the security of the data content, each user acting as a building occupant can choose from the respective list of demo sites as shown in Figure 7 (b), and according to their email account, they will be assigned to visualize data and results from a specific demo site only. Ubitech will continue to have an admin role until all the activities have been finished. Other key technical partners will use a predefined TEST account. What has been agreed for now is summarised in the following table:

Table 1 – Data availability to stakeholders

Stakeholder email extension	Demo site
um.es	UMU
kataskeuastikimakedonias.com	KAMA
siemens.com	TEST
suite5.eu	TEST

odins.es	UMU
ardenenergy.ie	ARDEN
miwenergia.com	MIW
skebit.se	SKE

Upon successful registration, the user is prompted to log in.

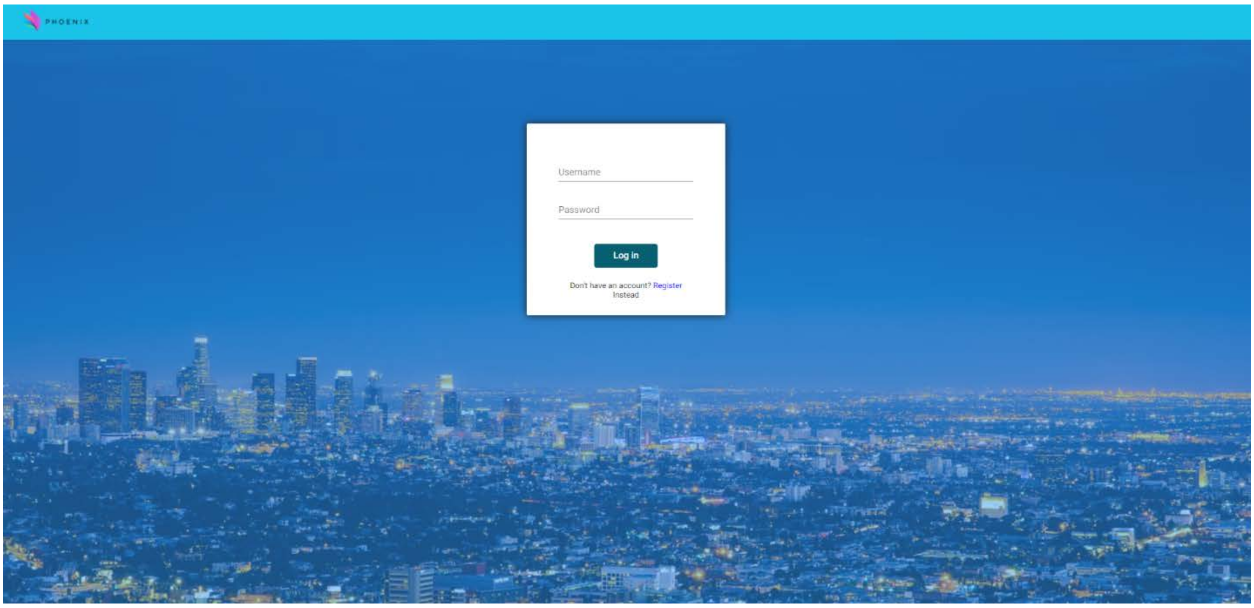


Figure 8 – Login screen

If the user provides wrong credentials the following informative error message will be displayed:

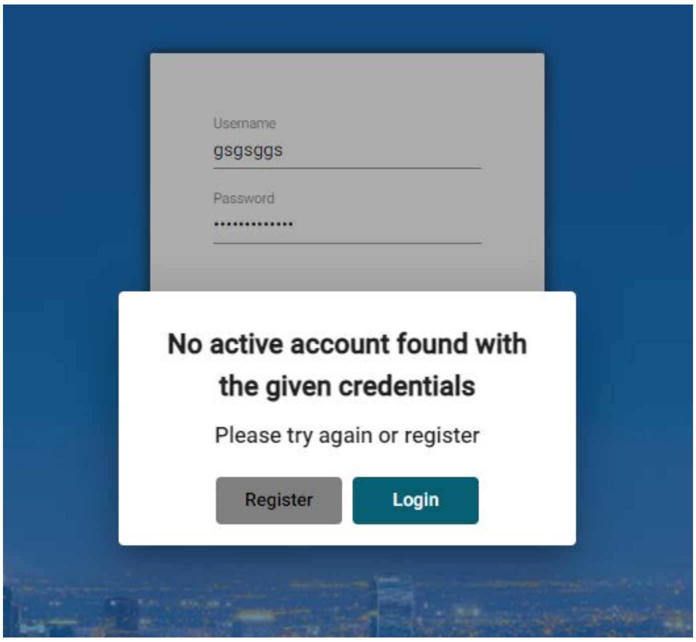


Figure 9 – Invalid username/password

Upon successful registration, each new user is prompted to complete a user survey that will help them to create a certain user profile for gaining a more personalized experience with the PHOENIX platform, i.e. declare user preferences regarding automation control, highlight comfort preferences and provide some demographic details to be potentially useful for linking the user's social profile with their energy behaviour. Figure 10 shows a sample of the user survey:

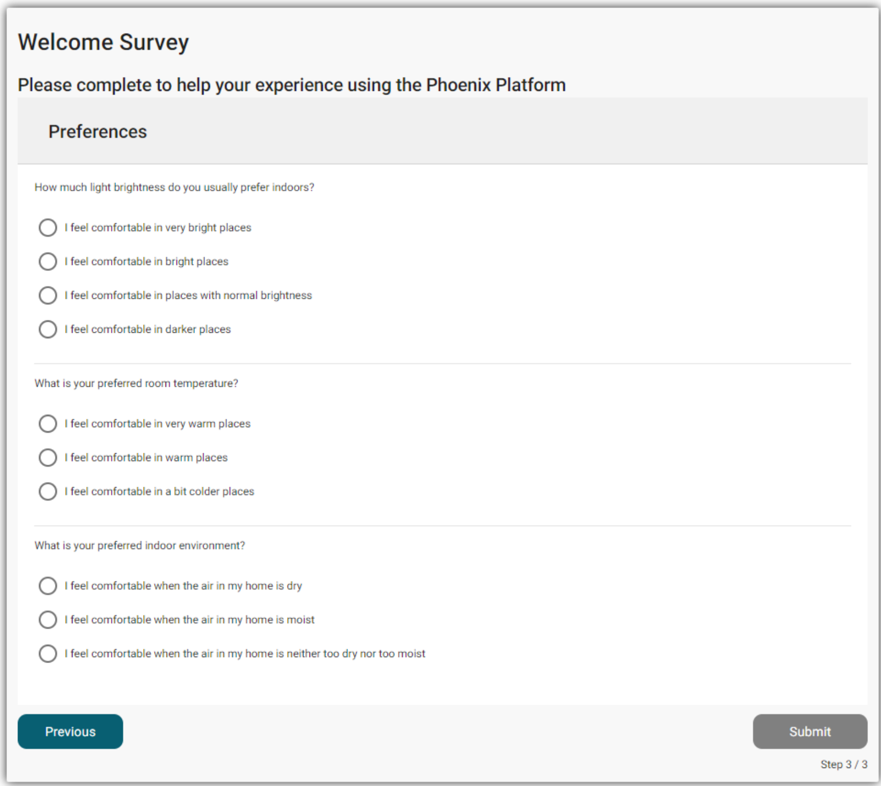


Figure 10 – Part of the welcome user survey

After completing successfully the survey, the user is prompted to "*At a Glance*" page where, for a specific building and zone, some general information is made available (for now Temperature, Humidity, Luminance and CO_2). The user can choose a different building from the dropdown menu on the sidebar.

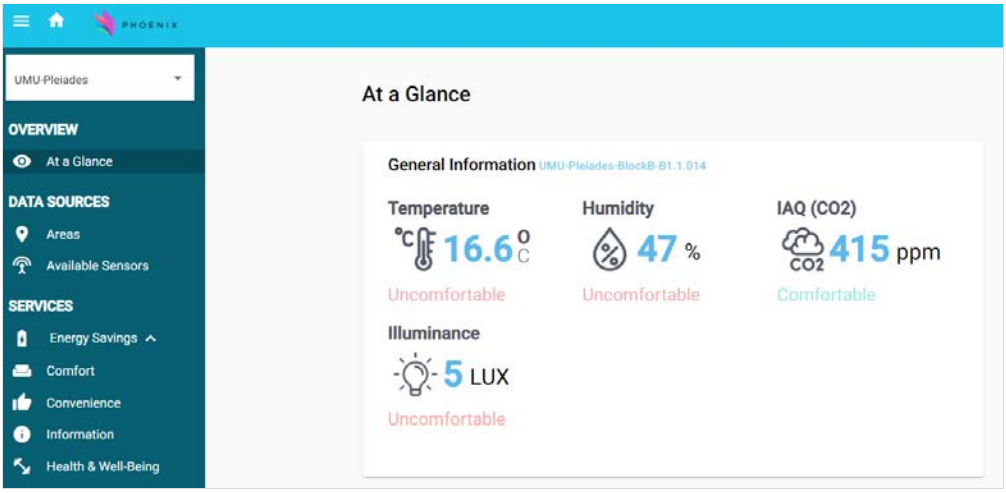


Figure 11 – A part of "*At a glance page*" in the dashboard for UMU Pleiades

If the user chooses "*Areas*", (s)he will be redirected to the respective zones of the selected building and for each zone the occupancy state is given (empty/occupied), calculated by the respective algorithm analysed in D4.2. For each zone there is a sensor button that will redirect to the respective sensors of the zone (or a selection of the most important ones), a button to edit the zone name (i.e. use an alias name) and a button to remove the respective zone from the "*Areas*" page. There will also be the possibility to add an area after removal using the button "*New Area*". The timer on the bottom right side indicates the user session timer which is by default 30 minutes but can be extended if the user wishes to do so.

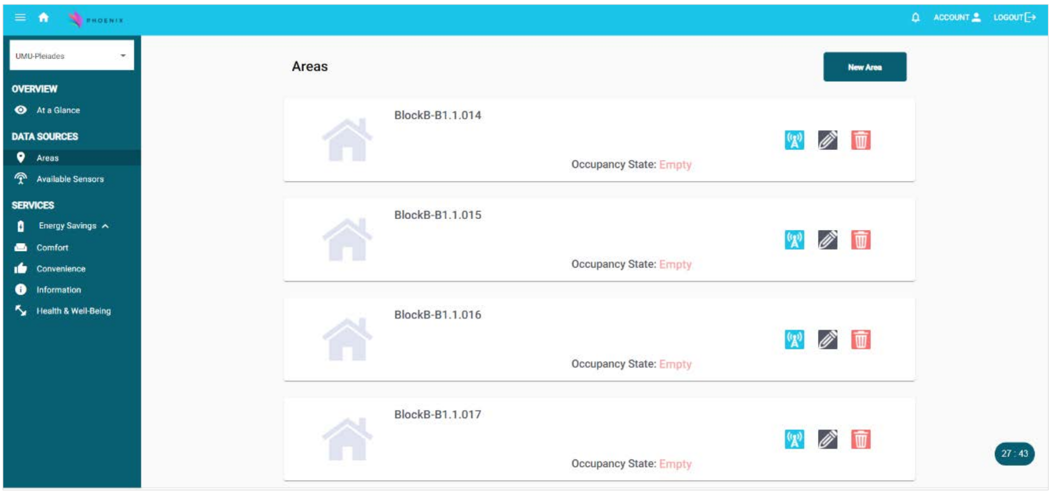


Figure 12 – "Areas" page for UMU Pleiades

The comfort-related Smart Readiness Indicators for buildings "*Comfort*" and "*Health & Wellbeing*" are directly linked to the user's answers in the comfort preferences section of the survey. The respective algorithms analysed in D4.2 are used to deliver to the UI the status of "*Comfortable*" or "*Uncomfortable*" for the default user thermal, visual and air quality comfort profile:

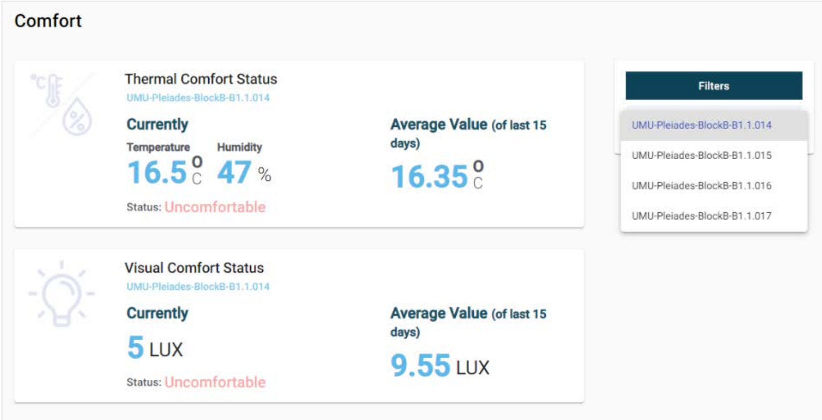


Figure 13 – Thermal and Visual measurements and comfort status for a given zone

Figure 14 – Air Quality measurements and comfort status for a given zone

Information about Energy consumption and Energy generation are of crucial importance to the building occupant. Regarding the energy consumption, and with a pre-selected building, the user can click on the "*energy savings*" tab and choose the option "*energy consumption*". Figure 8 shows an example regarding UMU-Pleiades total building's energy consumption in kWh from 06/03/2022 – 12/-03/2022. From the left dropdown "*Per Day*" the user will have the option to choose also "Per hour" depicting energy consumption of the last 24h and of course this can be extended to per Week and per Month options. We should be noting here that because these kinds of dynamic graphs are user-defined (click based) their reconstruction takes some seconds. This has been spotted as a performance issue and will be optimized in the final version of the dashboard.

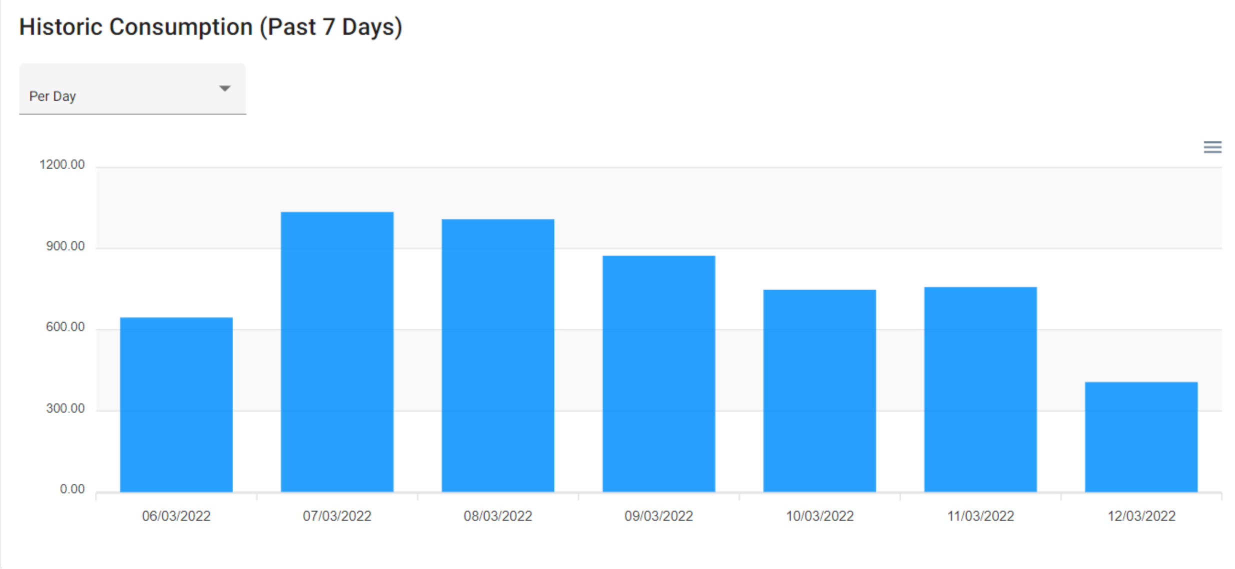


Figure 15 – Historic Energy consumption of UMU-Pleiades

Figure 16 below shows the corresponding building energy generation in kWh when the user chooses "*energy generation*" in the "*energy savings*" button, for 6 and 7 of March. Another interesting feature of this kind of graphs is a small dropdown menu in the upper right of the graph where the user has the option of download the x-y axis values in CSV format, download the graph as a .png image or open it in another page .svg format.

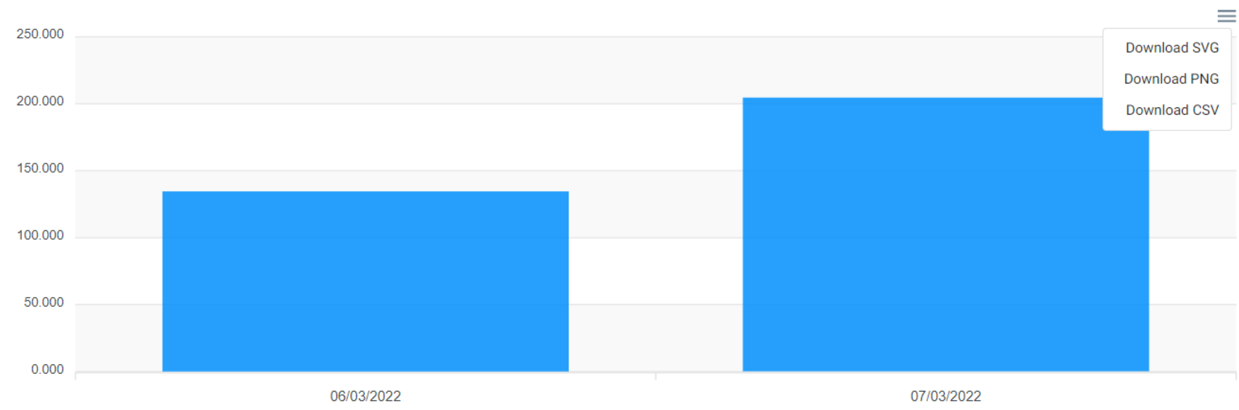


Figure 16 – Historic Energy generation from the PV installed in UMU-Pool-Parking

Finally, a preliminary version of the recommendations to occupants is presented in Figure 17. By clicking on the "*Information*" page, the users can view a short history of the recommendations/notifications delivered to them by the *Comfort, Health and Wellbeing Notification Engine*. Each notification can be star-rated from 1 to 5 stars and the results from the rating can be used to improve the human-building interaction by truly understanding each individual's needs in terms of a comfort-preserving environment.

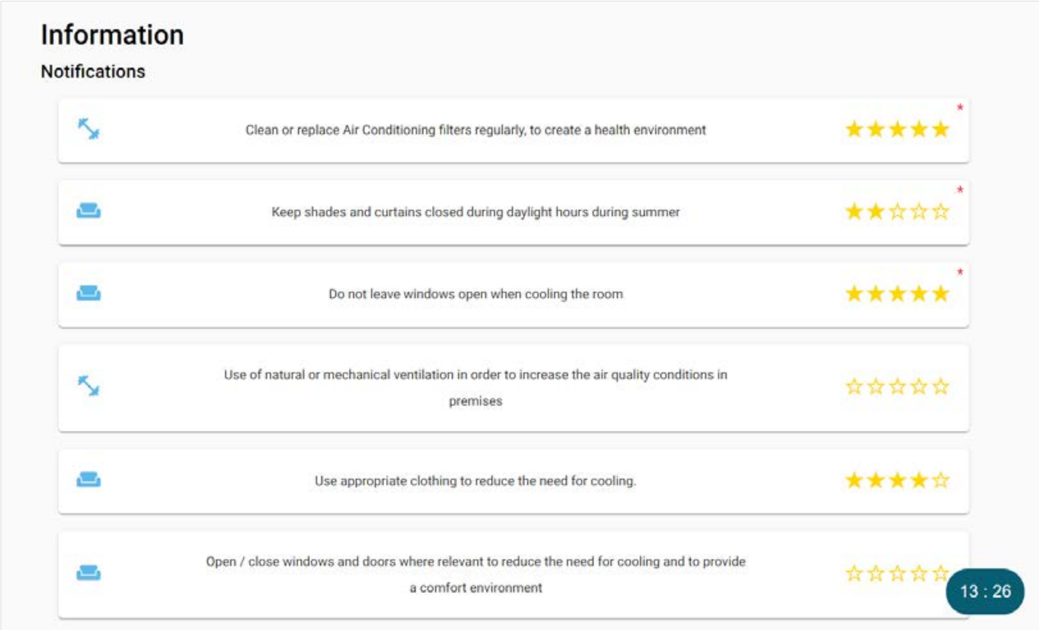


Figure 17 – Examples of recommendations to the building occupants

5 Integration, testing and refinement framework

Software testing is the process of evaluating a software product to find whether the current product meets the required conditions or not. There are many types of software testing nowadays, the most commonly used are the following:

- Unit testing: It helps developers to know whether the individual unit of the code is working properly or not.
- Integration testing: It helps developers to know whether the integrated units are working properly or not.
- Regression testing: It is a full or partial selection of existing test cases to ensure that existing functionality is not broken after the introduction of new code.

In the case of web applications though, end to end testing is normally used for testing the full flow of an application. The goal of such a test is to interact with the application like an end user does. Each testing scenario can have multiple steps and one or more assertions can be used for each step. Though for the dashboard development a series of manual end to end tests have been practiced in the beginning, the process took plenty of time, and was error prone as many important workflows could be missed.

That is why the idea of using a framework for test automation has been examined and is described in Annex I – Testing with Cypress.

An initial set of test scenarios has been formulated (the list will be enhanced for the upcoming deliverable), as shown below in Table 2.

Table 2 – Proposed test cases

ID	Description
TC_01	Verify that the dashboard application is running at https://dashboard-eu-phoenix.euprojects.net/
TC_02	Verify that a new user of role occupant can be successfully registered.
TC_03	Verify that an existing user cannot be registered twice.
TC_04	Verify that an authenticated user can successfully login.
TC_05	Verify that a non-authenticated user cannot successfully login.
TC_06	Verify that a user after his first login gets redirected to a user survey and completes it successfully.
TC_07	Verify that a user after his second login gets redirected to at a glance page.
TC_08	Verify that a user logout is successful.
TC_09	Verify that a user is logged out after 30 minutes unless he refreshes the session timer.
TC_10	Verify that a user can select from a list of buildings.
TC_11	Verify that a user can select from a list of zones.
TC_12	Verify that a user can have real time information about temperature, humidity, CO_2, luminance per zone
TC_13	Verify that a user can have real time information about the occupancy state per residential building zone.
TC_14	Verify that a user can have real time information about the default thermal comfort status per residential building zone.
TC_15	Verify that a user can have real time information about the default visual comfort status per residential building zone.
TC_16	Verify that a user can have real time information about the default indoor air quality comfort status per residential building zone.

6 Conclusions

This document describes the work performed within WP5 to develop services in a real scenario with real devices. So far, most of the work has been based on simulations and algorithms, but now it is time to put all this theory into practice in the pilot cases.

In terms of integration with other components of the PHOENIX Smartness Hub, services are already using the S&P framework designed in WP4 and therefore all the information flows between the services and the platform components are exchanged in a secure way.

An important aspect to highlight at this stage of the project is the availability of a user access to the services through the Dashboard, letting users know what is actually happening underneath. This is a critical point as improvements and updates on services will be quickly available through a user-friendly environment.

From a testing perspective, the definition of a methodology for defining tests has been introduced. As stated at the beginning of this document, T5.4 and T6.4 may share some contents, tools and strategies in order to provide a variety of options for service developers so that they can choose the one that better fits their needs depending on their requirements. The alternatives introduced in the context of T6.4 will be included in D6.2.

7 Annex I – Testing with Cypress

For this WP, the Cypress framework has been analysed as an all-in-one testing framework, assertion library offering mocking and stubbing capabilities. Cypress tests anything that runs in a web browser.

Cypress is executed in the same run loop as your application. Behind Cypress is a Node.js server process. Cypress and the Node.js process constantly communicate, synchronize, and perform tasks on behalf of each other. Having access to both parts (front and back) gives the ability to respond to the application's events in real time. Cypress ultimately controls the entire automation process from top to bottom, which puts it in the unique position of being able to understand everything happening in and outside of the browser. The installation is very simple as it is another npm package for the dashboard angular frontend.

In general, a solid test generally consists of 3 phases:

- Set up the application state.
- Take an action to the application that causes it to change.
- Make an assertion about the resulting application state.

More specifically, each dashboard test case will try to cover:

1) Visit a web page.
2) Query for an element.
3) Interact with that element.
4) Assert about the content on the page.

Below we include a test template for a specific end-to-end scenario:

Test Case ID	TC_01	**Test Case Description**	Verify that a new user of role occupant can be successfully registered.

Tester's Name	Giannis Bregiannis	**Date Tested**	1-March-2022	**Test Case (Pass/Fail/Not Executed)**	Pass

S #	Prerequisites:
1	Access to a Browser
2	
3	
4	

S #	Test Data
1	Username = test
2	Email = test@gmail.com
3	Password = test
4	First Name = John
5	Last Name = Doe
6	Role = Occupant
7	Demo = UMU

Step #	Step Details	Expected Results	Actual Results	Pass / Fail / Not executed / Suspended
1	Navigate to https://dashboard-eu-phoenix.euprojects.net/	Site should open	As Expected	Pass
2	Enter User Details	Credentials can be entered	As Expected	Pass
3	Click Sign up	User is logged in	As Expected	Pass
4				
..				