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| Abstract:   |
|---|
| The present document reports on the implementation and testing of the WiseHOME app. The software implementation has been based on the design reported in D11.1 and the testing concerns unit and alpha testing, performed in-house under the supervision of the development team. The document also includes a user manual to guide perspective users through the process of registering to and using the web app in a daily context. |

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## Executive Summary

The WiseHOME app is the tool of the WiseGRID tool chain that serves as the interface with the residential electricity consumer or prosumer. Its goal is to provide a deep and comprehensive understanding of the energy consumption and production of the household to the user, in order to raise awareness about how energy is used, e.g. its time profile, what is the impact on total electricity intake from the grid, etc. In addition to this, WiseHOME will also inform the user about the state and performance of other assets he may have in the home, such as local generation, stationary batteries or EVs for instance. Finally, WiseHOME will also serve as the interface toward the user for the deployment of implicit (price-based) demand response campaigns by the supplier and/or cooperative within the context of the WiseGRID project. In essence, WiseHOME aims to become an innovative tool through which retailers, cooperatives and aggregators can establish communication channels with their customers in order to solidify their loyalty via awareness about consumption patterns as well as delivery of personalised triggers for energy demand modulation. This channel will effectively become the enabler for the empowerment of active citizen participation in the energy system.

The present report documents both technical aspects of the WiseHOME app implementation as well as a user manual to aid users to start using the tool. As far as the technical aspects are concerned – and building on the material of Deliverable D11.1 which documented the design details for WiseHOME, this document outlines i) the WiseHOME architecture including the software technologies used for its implementation, ii) updated specifications on the information exchange with the other products of the WiseGRID ecosystem, iii) the testing process used to verify the correct functionality of the app. The user manual aims to guide the user step-by-step through the entire process that starts with registration to the WiseHOME app all the way to using it in an everyday context.

## 1 Introduction

### 1.1 PURPOSE OF THE DOCUMENT

The purpose of the present report is to document the outcome of the implementation and testing process for WiseHOME, based on the design outlined in Deliverable D11.1. Implementation and testing was performed entirely in-house, a next testing phase – equivalent to beta testing – will be carried out during the integration activities of the project (WP14 “Integration and deployment of WiseGRID ecosystem”) whereby individuals external to Hypertech will be called to test the WiseHOME app.

The material reported in this document reflect the consensus among several technology and pilot partners in the WiseGRID project regarding how to optimally deliver information to residential energy consumers. This document aims to guide the reader through the process and its intermediate outcomes so as to aid understanding about the choices and constraints that lead to the final implementation.

*Disclaimer: all the data shown in the WiseHOME app user interface throughout this report are dummy and do not represent relevant information from a real household. They are placeholder data to test the interconnection and communication between WiseGRID products. Real information (e.g. smart meter measurements) will become available during the WiseHOME app integration with the WiseGRID product ecosystem, which is an activity of Work Package 14. The placeholder data, however, are adequate to showcase the functionality and the usage scenarios for the WiseHOME app.*

### 1.2 SCOPE OF THE DOCUMENT

This document reports the findings from the software implementation and testing process of the WiseHOME app. It includes:: i) an adaptation of the architecture description based on the necessary modification made during software development; ii) updated specifications regarding the message exchange with the WiseCOOP tool that support validity checking of user information and notifications; iii) test setup and findings of the testing procedure; and iv) visualised user manual for the perspective user of the application.

### 1.3 STRUCTURE OF THE DOCUMENT

The document is structured as follows:

- Chapter 2 briefly explains how WiseHOME fits in the overall architectural diagram of the WiseGRID product ecosystem;
- Chapter 3 documents the architecture, the deployment view and several technical aspects of the WiseHOME tool;
- Chapter 4 documents in detail the requirements for the information that will have to be provided to WiseHOME so that the latter visualises it for the user;
- Chapter 5 is a brief user manual of the WiseHOME app presenting the app functionality, screens and main processes in a simple manner;
- Chapter 6 documents the results of the testing procedures that were applied to ensure that the application works as expected and satisfies its specifications.

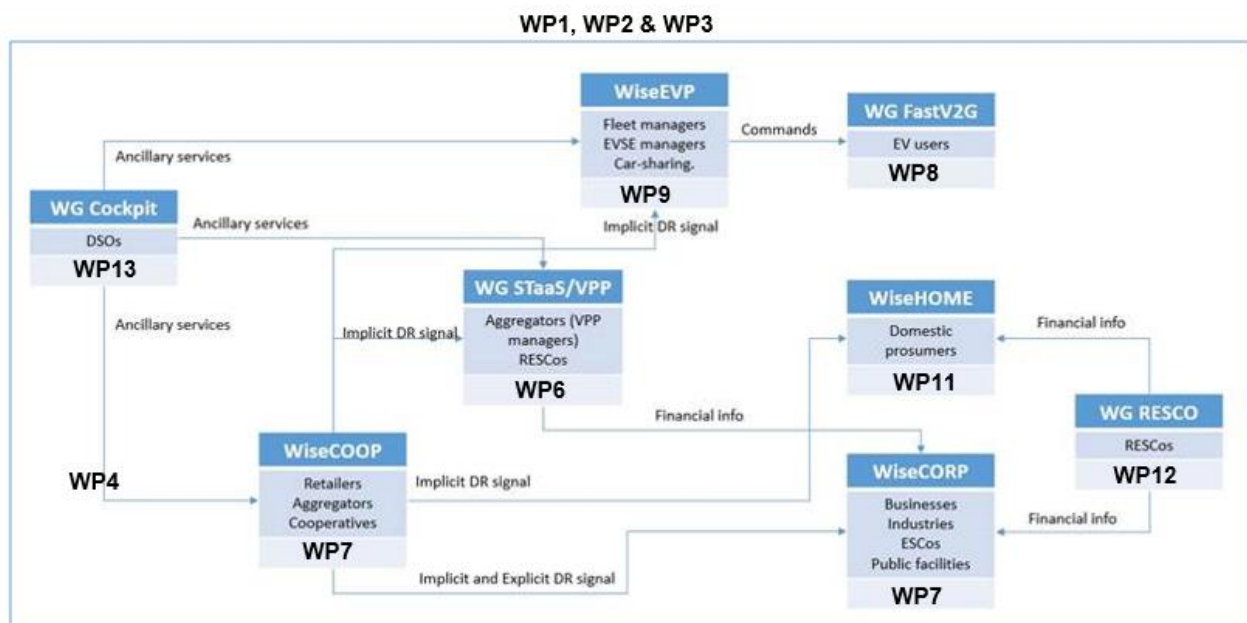
## 2 WiseHOME as an Integral Components of the WiseGRID DR Flow

The WiseHOME application is the dedicated user interface for residential consumers and prosumers who want to take part in the WiseGRID ecosystem, or parts of it enabled by market actors such as retailers or energy cooperatives.

The figure below provides a snapshot of the tools that comprise the WiseGRID ecosystem, including:

- The target users of each tool, and
- The high-level interactions among tools expressed signals for the preparation and/or activation of services they provide to one another or to the grid.

The WiseHOME app is positioned as a tool for the domestic consumer or prosumer – it is actually the only tool that directly interfaces domestic users. It interacts with other tools, such as WiseCOOP and WG RESCO in order to properly exchange the necessary information that will enable it to provide the target services to its user.



**Figure 1 - High-level WiseGRID ecosystem architecture**

More details about the interaction between WiseHOME and the other WiseGRID tools are provided below:

**WiseHOME & WiseCOOP:** this is the main interaction that is foreseen in the project as any residential consumer or prosumer will have a commercial relationship with a retailer. WiseHOME will serve as the user interface, which the retailer will utilise to convey information to its customers.

**WiseHOME & WG RESCO:** the intention of this interaction is to inform the prosumers who have provided their space (e.g. rooftops) for installation of renewable generation sources about the benefits they are entitled to from the RESCO. These will be mainly financial benefits that can be seen as rewards for the home owner.



### 3 WiseHOME Architecture

This chapter aims to make the reader aware of the internals of the WiseHOME software architecture as well as implementation details, e.g. technologies, deployment, etc. The WiseHOME is primarily a web app – which means that its front-end is prominent as it is the component that is visible to the end user – but the bulk of the implementation is in the back-end where all the material for visualisation is created.

#### 3.1 INFORMATION SOURCES

The WiseHOME application is meant to be a tool that is offered by retailer and / or other Smart Grid actors to the customers/ members so that the latter can have enhanced observability on their energy-related activities, including energy consumption, generation, cost, etc. It is especially tuned for active energy consumers and cooperative members, it has a separate view for collective reports that illustrate the performance of the entire group of consumers (be they customers of the same retailer or members of the same cooperative) that illustrate information about the grid friendliness or the CO<sub>2</sub> intensity of the collective consumption.

It is thus evident that WiseHOME is not a standalone application, but is encapsulated in a wider ecosystem in order to function properly and achieve its business objectives – which directly reflect the objectives of the cooperative or retailer. On a more technical note, this has direct consequences on the management of the information that is visualised by WiseHOME. All of the information is available to the corresponding retailer/ cooperative and some of the information is exclusively available to these parties.

Within the WiseGRID product ecosystem, retailers and cooperatives are envisaged to use the WiseCOOP product in order to manage their daily activities. Everything from standard billing activities to more novel demand response campaign management will be handled by this product. As a result, it has been collectively decided within the consortium that all dynamic information that will be visualised by WiseHOME will be retrieved from the WiseCOOP tool. Dynamic, in this context, means all information apart from user credentials (that will be locally managed by WiseHOME) and basic configuration information that is necessary in order to identify the user (e.g. home ID and cooperative ID). All other information will be retrieved from WiseHOME on the fly for visualisation purposes using the message specifications described in Section 4. This decision has important positive repercussions on security and data privacy as well. It will make it much easier for the WiseGRID tools to handle any request from a user to provide or even delete any piece of information (owned by the user) that is stored within the WiseGRID system.

#### 3.2 SECURITY CONSIDERATIONS

Data security and privacy is of utmost importance for the WiseHOME app and for the WiseGRID ecosystem as a whole. As a result, the design and implementation of the WiseHOME app took into account from the beginning a number of relevant requirements to ensure that user data will not be compromised.

State of the art techniques and mechanisms will be used to achieve this goal:

- Secure communications using the https protocol with information encryption under TLS1.2 [1];
- Username & password hashing for local storage security.

In addition to the aforementioned tools, it is even more important to mention that WiseHOME will store information that is not sensitive or personal in nature, because it will not have all the necessary information to identify individuals. The pieces of information that will be asked from the user in order to complete the registration will be the following:

- Home ID: a unique ID that is provided by the WiseCOOP operator and corresponds to the customer ID in the WiseCOOP product;
- Cooperative / retailer with whom the user has an active commercial engagement: this information will dictate which instance of WiseCOOP will be probed to obtain the information for visualisation;
- Username: an alias of choice of the user, it does not have to be linked to his/her name;
- Password: in order to authenticate users when accessing the WiseHOME app;
- E-mail: the user will be able to ***optionally*** provide his/her e-mail address so as to receive notifications via e-mail.

### 3.3 WISEHOME ARCHITECTURE

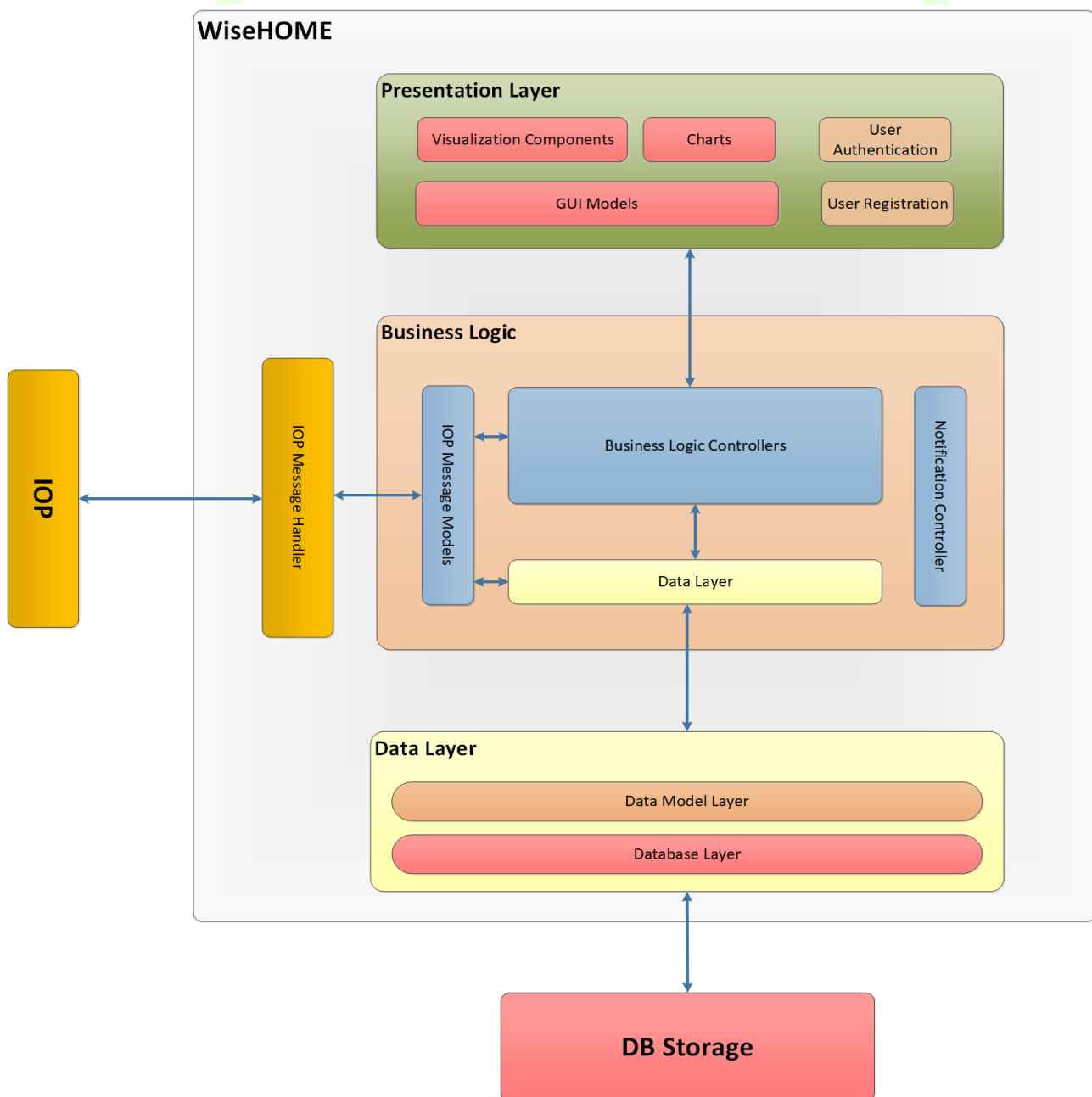


Figure 2 - High-level software architecture of the WiseHOME product

Figure 2 depicts the software architecture of the WiseHOME software, focusing on the back-end that performs all the necessary communications and processing in order to generate and send the HTML that is rendered on the user's browser.

The following paragraphs briefly describe the purpose of each of the components.

### 3.3.1 DB Storage

The back-end of the WiseHOME app needs a persistent data storage facility. The information to be stored there is minimal, but since WiseHOME will perform the user management (registration, authentication, etc.) it requires access to persistent storage.

### 3.3.2 Data Layer

Responsible for model, orchestrate and manage relational databases.

### 3.3.3 IOP Message Handler

Responsible for establishing connection with IOP (RabbitMQ configurations), handling messages and wrapping them to the respective **IOP Message Models**.

#### IOP Message Models

Data models of all respective messages. More information about these messages is documented in the following project deliverables:

- D4.2 WiseGRID interoperable Integrated Process (WG IOP);
- D7.1 WiseCOOP and WiseCORP Apps Design;
- D10.2 DR Framework Specifications.

### 3.3.4 Business Logic

#### Business Logic Controllers

Contains the core functionality and the business logic of WiseHOME app. Orchestrates the different components in order to be served on the presentation layer.

### 3.3.5 Presentation Layer

#### GUI Models

As we follow the MVC Architecture as software methodology approach, every aspect should be modelled in order to be manipulated by the Business Logic Layer. GUI Models refer on modelling every UI aspect in terms of Chart Graphs, Chart Pies, other Visual Components etc.

#### Visualization Components

Visualization of components such as:

- Traffic lights

- Pie Component
- Gauges Component
- Information modules

#### Chart Components

Chart Plots such as:

- Line time series
- Area time series
- Comparative charts

#### **3.3.6 Notifications controller**

The notification controller module is responsible for displaying the appropriate notifications in the WiseHOME front-end. Notifications are displayed in two different ways:

- As messages in the top menu of the WiseHOME app screen
- As native notifications of the operating system and browser, but exceptions apply in this case. Native notifications are delivered to all MS-Windows and Android powered devices using popular browsers such as Chrome, Firefox, Edge, etc. Devices powered by iOS or MacOS are not supported due to limitations imposed by the Apple ecosystem. The work-around, in this case, is to inform the user via SMS or e-mail about an upcoming notification from the retailer/cooperative. Such an approach emulates the result of a native notification, assuming that the user's mail client pushes native notifications to the device.

The baseline assumptions made regarding the relationship between notifications, users, residences and devices is the following:

- The WiseCOOP operator (retailer/cooperative) only knows his/her customers as residential grid connections;
- Several people can live in the same home and, hence, they will share the same home ID in the WiseHOME app;
- People can access the WiseHOME app from any device that has an internet browser, e.g. desktop PCs, laptop PCs, tablets, smartphones;
- The WiseCOOP operator effectively wants to influence the energy consumption of the home, so any notification sent should reach all associated users across all their devices;
- The WiseHOME application server will be responsible for sending notifications to all appropriate users and devices – as long as the users have accepted to receive notifications.

WiseHOME supports notification types/priorities in order to allow the retailer/cooperative to leverage their semantics and allow the user to easily understand the importance/severity of the message. Three priorities are supported and the retailer/cooperative can customise the notification body (e.g. text, icon) in order to comply with their expectations on priorities.

#### **3.3.7 Implementation technologies**

The implementation of the WiseHOME application involves a number of different technologies. The paragraphs below indicate which implementation technologies are involved in each aspect of the implementation.

### **Core WiseHOME app (MODEL – CONTROLLER Aspect)**

- **Hibernate 5:** Framework for persistent DB modelling and Java DB Query language.
- **SpringMVC:** Java application framework, used in a wide range of Java applications. It was used for the development of the core J2EE applications. For specific aspects of the implementation Spring MVC packages were used, namely Spring Web and Spring Security Frameworks for web applications and authentication/authorization respectively.
- **Java 8:** Programming language.

### **Front End (VIEW Aspect)**

- **HTML/HTML5:** Mark-up language that enables the delivery of rich visualisation through a browser.
- **JSP:** Java Server Pages was used for the dynamic generation of web pages based on HTML, XML and other document types.
- **JSP Tiles:** Technology for the generation of page fragments which can be assembled into a complete page at runtime. It was used in order to reduce the duplication of common page elements or embedded within other tiles to develop a series of reusable templates.
- **jQuery:** Cross-platform JavaScript library designed to simplify the client-side scripting of HTML.
- **CSS3:** Language that defines the style of web pages, CSS3 is the latest version of the standard CSS language.
- **D3.js:** JavaScript library for visualizing data with HTML, SVG, and CSS. Responsible for all the visual and chart components.

### **Database**

- **MySQL Server:** the WiseHOME database is based on this technology. A separate database was used to store only the necessary information locally (at the deployment site of the entire back-end WiseHOME core) without communicating them over the WG IOP.

### **Web Services**

- **RabbitMQ (AMQP):** the WG IOP – the main communication infrastructure of the WiseGRID product ecosystem – is based on the RabbitMQ framework, so the WiseHOME app also includes wrappers to interface with it.
- **REST JSON:** internal communications of the WiseHOME implementation rely on this architectural style.

### **Logging & infrastructure**

- **Log4j:** Logging framework used to manage the framework.
- **Maven:** Tool used to manage the software project. Maven can manage a project's build, reporting and documentation from a central piece of information.
- **Tomcat 8:** Application server
- **Apache:** Web Server, load balancer.

### **Native notifications**

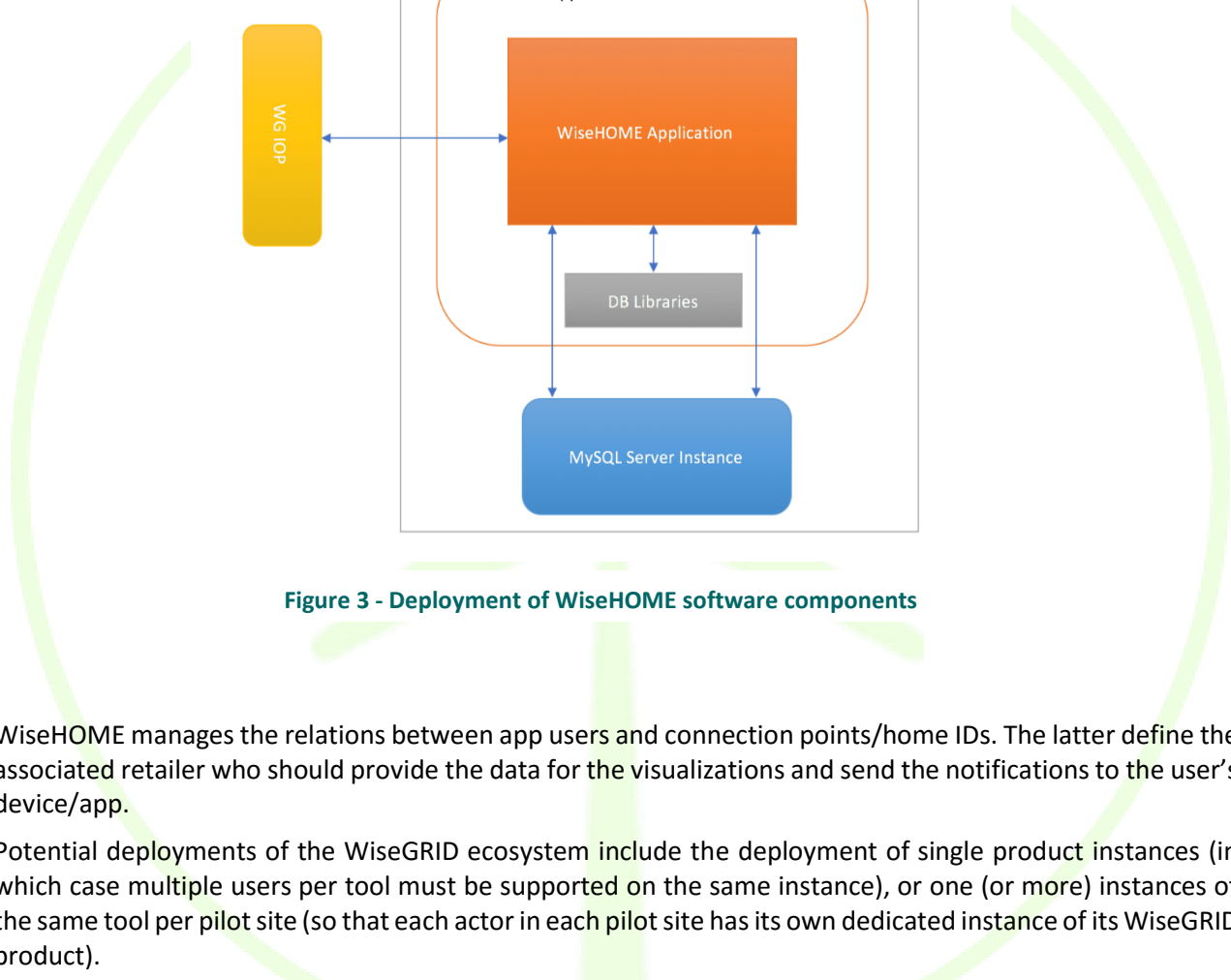
- **Bouncy Castle:** Java APIs for CMS, PKCS, EAC, TSP, CMP, CRMF, OCSP, and certificate generation.
- **Web-Push:** Tool used for asynchronous transactions between publisher or central server and client.

- **Service workers:** A script that runs in the background of the client's browser, separated from the web app, enabling features that don't need a web page or user interaction, such as Push Notifications.
- **Google Firebase:** formerly known as Google Cloud Messaging (GCM), is a cross-platform cloud solution for messages and notifications for Android, iOS, and web applications.

### 3.4 WISEHOME DEPLOYMENT

Figure 3 illustrates the expected deployment of the software components described in the previous subsection. All the relevant components will be deployed on the same machine, which will be a private cloud in the premises and fully controlled by a consortium partner, e.g. Hypertech in this specific case.

This machine will host all the necessary functionalities in a local application server instance as well as an instance of web server and a database instance. Should scalability issues arise due to extensive use of the WiseHOME during the demonstration activities, this setup can be replicated to further machines within company premises. For purposes of commercial exploitation of the WiseHOME app, this software bundle may be moved in the future to a server hosted by a cloud service provider in order to improve its scalability and reliability.



Potential deployments of the WiseGRID ecosystem include the deployment of single product instances (in which case multiple users per tool must be supported on the same instance), or one (or more) instances of the same tool per pilot site (so that each actor in each pilot site has its own dedicated instance of its WiseGRID product).

The WiseHOME app has been designed and implemented in order to support a range of possible deployment options for the rest of the WiseGRID product ecosystem in order to facilitate any business model that can be enabled by the various deployment options.





## 4 Integration with Data Sources

### 4.1 INFORMATION SOURCES

The WiseHOME application is envisaged to become a tool provided by retailers, cooperatives and aggregators to their customers or members in order to stimulate their awareness and engagement with energy-related issues. As such, the application will be owned and offered by these actors and as a result all the information required for visualizations will be contained in the WiseCOOP databases.

This chapter will provide more details regarding the information required for the visualizations, including descriptions and message specifications in order to ease the integration efforts.

Information requests will be published to the WG IOP via specific messages. These messages will be received by the appropriate instantiation of WiseCOOP – the one of the retailer/ cooperative/ aggregator – who has the respective building in its customer portfolio. WiseCOOP should interpret the messages based on the definitions provided below and prepare and publish the corresponding response to the WG IOP.

### 4.2 INFORMATION REQUIREMENTS

The WiseHOME application will rely on information from other tools in order to show the necessary visualizations to the home resident. This information is summarised in the following tables per tab of the web application and for the reference time periods defined in collaboration with the perspective customers of the WiseHOME app.

#### 4.2.1 Individual report tab of WiseHOME app

**Table 1 – Information requirements from WiseCOOP for the visualisation of the individual reports**

| WiseHOME Tab       |                            | Reference Period   |   |   |   |
|--------------------|----------------------------|--|---|---|---|
| Individual Reports |                            | Day  | Week  | Month   | Year  |
| Widget 1:          | <b>Instantaneous Power</b> | <b>Required Data</b>   |   |   |   |
|                    |                            | Instantaneous Power Consumption  |   |   |   |
|                    |                            | Connection Capacity  |   |   |   |
| Widget 2:          | <b>Energy Consumption</b>  | <b>Cumulative energy consumption visualization</b>                       |   |   |   |
|                    |                            | Cumulative daily energy consumption until now (<=24h)                    | Cumulative weekly energy consumption until now (<=7 days)                                       | Cumulative monthly energy consumption until now (<=1 month)                               | Cumulative annual energy consumption until now (<=12 months)                        |
|                    |                            | Cumulative energy consumption for the same calendar day of previous year | Cumulative weekly energy consumption for the same week of previous year until corresponding day | Cumulative energy consumption for the same month of previous year until corresponding day | Cumulative energy consumption during the same previous year until corresponding day |
|                    |                            | Cumulative energy consumption for the                                    | Cumulative energy consumption for the whole   | Cumulative energy consumption for the full month of previous year                         | Cumulative energy con-  |

|                  |                      |  |   |   |   |
|------------------|----------------------|--|---|---|---|
|                  |                      | same day (24h)<br>of previous year   | week (7 full days)<br>of previous year  |   | sumption dur-<br>ing the entire<br>previous year  |
|                  |                      | <b>Energy consumption time-series</b>  |   |   |   |
|                  |                      | Energy con-<br>sumption time-<br>series until now<br>(≤24h) in 15<br>min intervals                                 | Energy consump-<br>tion time-series<br>until now (≤7<br>days) in 6 hour in-<br>tervals  | Energy consump-<br>tion time-series<br>until now (≤1<br>month) in daily<br>intervals  | Energy con-<br>sumption un-<br>til now (≤12<br>months) in<br>weekly time<br>intervals   |
|                  |                      | Energy con-<br>sumption time-<br>series for the<br>same calendar<br>day of previous<br>year in 15 min<br>intervals | Energy consump-<br>tion time-series<br>for the same<br>week of previous<br>year until corre-<br>sponding day in<br>6-hour intervals | Energy consump-<br>tion time-series<br>for the same<br>month of previ-<br>ous year until cor-<br>responding day in<br>daily intervals | Energy con-<br>sumption<br>time-series<br>during the<br>same previous<br>year until cor-<br>responding<br>day in weekly<br>time intervals |
|                  |                      | <b>Cumulative electricity source information</b>   |   |   |   |
| <b>Widget 3:</b> | <b>Energy Source</b> | Cumulative grid-<br>imported elec-<br>tricity con-<br>sumed this day<br>until now                                  | Cumulative grid-<br>imported electric-<br>ity consumed this<br>week until now   | Cumulative grid-<br>imported electric-<br>ity consumed this<br>month until now  | Cumulative<br>grid-imported<br>electricity con-<br>sumed this<br>year until now   |
|                  |                      | Cumulative PV<br>generation dur-<br>ing the current<br>day until now   | Cumulative PV<br>generation during<br>the current week<br>until now   | Cumulative PV<br>generation during<br>the current<br>month until now  | Cumulative PV<br>generation<br>during the cur-<br>rent year until<br>now  |
|                  |                      | Cumulative<br>feed-in during<br>the current day<br>until now   | Cumulative feed-<br>in during the cur-<br>rent week until<br>now  | Cumulative feed-<br>in during the cur-<br>rent month until<br>now   | Cumulative<br>feed-in during<br>the current<br>year until now   |
|                  |                      | Time-series of<br>grid-imported<br>electricity con-<br>sumed this day<br>until now in 15<br>min intervals          | Time-series of<br>grid-imported<br>electricity con-<br>sumed this week<br>until now in 6-<br>hour intervals                         | Time-series of<br>grid-imported<br>electricity con-<br>sumed this month<br>until now in daily<br>intervals                            | Time-series of<br>grid-imported<br>electricity con-<br>sumed this<br>year until now<br>in weekly in-<br>tervals                           |
|                  |                      | Time-series of<br>local PV genera-<br>tion during the<br>current day un-<br>til now in 15<br>min intervals         | Time-series of PV<br>generation during<br>the current week<br>until now in 6-<br>hour intervals                                     | Time-series of PV<br>generation during<br>the current<br>month until now<br>in daily intervals  | Time-series of<br>PV generation<br>during the cur-<br>rent year until<br>now in weekly<br>intervals                                       |

|           |            |  |   |   |   |
|-----------|------------|--|---|---|---|
|           |            | Time-series of feed-in during the current day until now in 15 min intervals                          | Time-series of feed-in during the current week until now in 6-hour intervals                          | Time-series of feed-in during the current month until now in daily intervals                          | Time-series of feed-in during the current year until now in weekly intervals                          |
| Widget 4: | Costs      | Cumulative cost information  |   |   |   |
|           |            | Cumulative energy cost of grid-imported energy for the current day until now                         | Cumulative energy cost of grid-imported energy for the current week until now                         | Cumulative energy cost of grid-imported energy for the current month until now                        | Cumulative energy cost of grid-imported energy for the current year until now                         |
|           |            | Daily PV operation costs   | Weekly PV operation costs   | Monthly PV operation costs  | Annual PV operation costs   |
|           |            | Time-series of cost information  |   |   |   |
|           |            | Time-series of energy cost of grid-imported energy for the current day until now in 15 min intervals | Time-series of energy cost of grid-imported energy for the current week until now in 6-hour intervals | Time-series of energy cost of grid-imported energy for the current month until now in daily intervals | Time-series of energy cost of grid-imported energy for the current year until now in weekly intervals |
|           |            |  |   |   |   |
| Widget 5: | Rewards    | Cumulative reward information  |   |   |   |
|           |            | Cumulative income from electricity feed-in to the grid for the current day until now                 | Cumulative income from electricity feed-in to the grid for the current week until now                 | Cumulative income from electricity feed-in to the grid for the current month until now                | Cumulative income from electricity feed-in to the grid for the current year until now                 |
|           |            | Cumulative income from participation in DR campaign for the current day until now                    | Cumulative income from participation in DR campaign for the current week until now                    | Cumulative income from participation in DR campaign for the current month until now                   | Cumulative income from participation in DR campaign for the current year until now                    |
|           |            |  |   |   |   |
| Widget 6: | Storage/PV | Real-time storage/generation information   |   |   |   |
|           |            | Battery Charging State   |   |   |   |
|           |            | Battery State of Charge (%)  |   |   |   |
|           |            | Instantaneous PV Generation Output   |   |   |   |

## 4.2.2 Collective reports tab of WiseHOME app

**Table 2 – Information requirements from WiseCOOP for the visualisation of the collective reports**

| WiseHOME Tab       |                         | Reference Period  |  |  |  |
|--------------------|-------------------------|---|--|--|--|
| Collective Reports |                         | Day   | Week   | Month  | Year   |
| Widget 1:          | <b>Local Generation</b> | <b>Cumulative cooperative electricity generation data</b>   |  |  |  |
|                    |                         | Cumulative grid imported electricity consumed by the cooperative during the current day until now                         | Cumulative grid imported electricity consumed by the cooperative during the current week until now                         | Cumulative grid imported electricity consumed by the cooperative during the current month until now                        | Cumulative grid imported electricity consumed by the cooperative during the current year until now                         |
|                    |                         | Cumulative PV generation from cooperative during the current day until now  | Cumulative PV generation from cooperative during the current week until now  | Cumulative PV generation from cooperative during the current month until now   | Cumulative PV generation from cooperative during the current year until now  |
|                    |                         | Cumulative electricity feed-in by cooperative during the current day until now  | Cumulative electricity feed-in by cooperative during the current week until now  | Cumulative electricity feed-in by cooperative during the current month until now   | Cumulative electricity feed-in by cooperative during the current year until now  |
|                    |                         | <b>Time-series of cooperative electricity generation data</b>   |  |  |  |
|                    |                         | Time-series of grid imported electricity consumed by the cooperative during the current day until now in 15 min intervals | Time-series of grid imported electricity consumed by the cooperative during the current week until now in 6-hour intervals | Time-series of grid imported electricity consumed by the cooperative during the current month until now in daily intervals | Time-series of grid imported electricity consumed by the cooperative during the current year until now in weekly intervals |
|                    |                         | Time-series of PV generation from cooperative during the current day until now in 15 min intervals                        | Time-series of PV generation from cooperative during the current week until now in 6-hour intervals                        | Time-series of PV generation from cooperative during the current month until now in daily intervals                        | Time-series of PV generation from cooperative during the current year until now in weekly intervals                        |

|           |  |  |   |  |   |
|-----------|--|--|---|--|---|
|           |  | Time-series of electricity feed-in by cooperative during the current day until now in 15 min intervals   | Time-series of electricity feed-in by cooperative during the current week until now in 6-hour intervals   | Time-series of electricity feed-in by cooperative during the current month until now in daily intervals    | Time-series of electricity feed-in by cooperative during the current year until now in weekly intervals   |
| Widget 2: | <b>CO<sub>2</sub> - Intensity Grid</b> |  |   |  |   |
|           |  | Average normalised CO <sub>2</sub> intensity for the current day (%)                                     | Average normalised CO <sub>2</sub> intensity for the current week (%)                                     | Average normalised CO <sub>2</sub> intensity for the current month (%)                                     | Average normalised CO <sub>2</sub> intensity for the current year (%)                                     |
| Widget 3: | <b>Grid friendly consumption</b>       | <b>Required Data</b>   |   |  |   |
|           |  | To what degree collective demand followed generation to maximise self-consumption during the current day | To what degree collective demand followed generation to maximise self-consumption during the current week | To what degree collective demand followed generation to maximise self-consumption during the current month | To what degree collective demand followed generation to maximise self-consumption during the current year |

#### 4.2.3 Information tab of WiseHOME app

**Table 3 – Information requirements from WiseCOOP for the visualisation of the cost information**

| WiseHOME Tab |                          | Reference Period  |  |  |  |
|--------------|--------------------------|---|--|--|--|
| Info         |                          | Day   | Week   | Month  | Year   |
| Widget 1:    | <b>Tariffs</b>           | <b>Electricity price information</b>  |  |  |  |
|              |                          | Flat electricity price (euro cents) per kWh   |  |  |  |
|              |                          | Time-series of dynamic price (euro cents) per kWh for the current day until now in 15 min intervals               | Time-series of dynamic price (euro cents) per kWh for the current week until now in 6-hour intervals               | Time-series of dynamic price (euro cents) per kWh for the current month until now in daily intervals               | Time-series of dynamic price (euro cents) for the current year until now in weekly intervals   |
| Widget 2:    | <b>Tariff Simulation</b> | <b>Energy cost information</b>  |  |  |  |
|              |                          | Time-series of energy bill (euros) information under flat price for the current day until now in 15 min intervals | Time-series of energy bill (euros) information under flat price for the current week until now in 6-hour intervals | Time-series of energy bill (euros) information under flat price for the current month until now in daily intervals | Time-series of energy bill (euros) information under flat price for the current year until now |

|  |  |  |   |   |   |
|--|--|--|---|---|---|
|  |  |  |   |   | in weekly intervals   |
|  |  | Time-series of energy bill (euros) information under dynamic price for the current day until now in 15 min intervals | Time-series of energy bill (euros) information under dynamic price for the current week until now in 6-hour intervals | Time-series of energy bill (euros) information under dynamic price for the current month until now in daily intervals | Time-series of energy bill (euros) information under dynamic price for the current year until now in weekly intervals |

#### 4.2.4 Horizontal requirements

In addition to the content-based requirements that are specified in the above tables, additional requirements include:

1. All aforementioned information should be searchable and retrievable via a unique ID (e.g. the smart meter ID)
2. Real-time measurements are required from all wrappers that implement interfaces to building devices in order to extract the device operational states

### 4.3 MESSAGE SPECIFICATIONS

WiseHOME will visualise information that will be obtained from the WiseCOOP product via the exchange of messages. This will happen in a request-response paradigm, whereby WiseHOME will publish requests for specific information in the WG IOP and the appropriate WiseCOOP instance – in case many are operational – will create and publish the appropriate response.

The following sub-sections define the details of the messages to be exchanged in order to ensure seamless information exchange.

#### 4.3.1 Structure of generic message part

Apart from the parts of the messages that are related to the energy-related information to be exchanged, a preamble in the messages is required so that the tools can manage the communications. The following table supplies the necessary information.

**Table 4 – Preamble specification for info exchange between WiseCOOP and WiseHOME**

| <b>NN</b> | <b>Name</b>             | <b>M/O</b> | <b>Values</b>  | <b>Description</b>  |
|-----------|-------------------------|------------|--|---|
| <b>1</b>  | <b>"Sender"</b>         | O          | sender product ID  | <i>Unique identifier of WiseHOME or WiseCOOP instance depending on which tool is sending the message</i>                    |
| <b>2</b>  | <b>"Recipient"</b>      | O          | recipient product ID   | <i>Unique identifier of WiseHOME or WiseCOOP instance depending on which tool is the target received of the message</i>     |
| <b>3</b>  | <b>"conversationID"</b> | O          | Unique ID generated by WiseHOME instance during request generation | <i>Unique ID of conversation that comprises a request and a response between specific WiseHOME &amp; WiseCOOP instances</i> |



|   |               |   |             |                   |   |
|---|---------------|---|-------------|-------------------|---|
| 4 | "messageType" | 0 | Enumeration | REQUEST, RESPONSE | <i>Specifies whether the message is a request for information sent from a WiseHOME instance or a response with information from a WiseCOOP instance</i> |
|---|---------------|---|-------------|-------------------|---|

This preamble includes the minimum required information so that products can associate messages to each other (e.g. responses with requests). The data fields are straightforward:

- Sender is the product that sends the message. WiseHOME will send the request and WiseCOOP will send the response. The most important aspect in this attribute is that it must specify exactly which instance of the two tools is the sender, in case multiple instances/deployments of WiseHOME and WiseCOOP are simultaneously active. For the WiseGRID purposes the WiseCOOP ID can be one of the pilot sites of the project, but in general any enumeration can be used.
  - The ID of each WiseHOME instance will be based on a combination of data from the username, the SMX ID and others.
  - The ID of the WiseCOOP instance will be one of the following: ECOPOWER, ENERCOOP, TERNI, HEDNO\_MES, HEDNO\_KYTH. The baseline assumption is that there will only one deployment of WiseCOOP instance per pilot site during the project pilot activities.
- Recipient is the target message recipient, same things apply as above.
- conversationID is a unique identifier that is common to a pair of request and response messages. It is a temporary value that has a lifetime starting from the generation of the request in WiseHOME and ending when the appropriate response from WiseCOOP is received. It will be used to keep track of message pairs that comprise a "conversation" in order to easily which data corresponds to which request.
- messageType is a field that specifies the type of the message, whether is a request or a response. It is useful for properly parsing and interpreting the message, even though semantically this information can be extracted from combinations of the other fields.
- Whether the contents of the generic message part will be used depends on the final configuration of the WG IOP. If the AMQP protocol is used with Virtual Hosts, then this information is redundant per message because the communication channel will be established up from between specific WiseCOOP and WiseHOME instances. Otherwise, this information may be needed per message.

#### 4.3.2 Structure of information request message from WiseCOOP



The following table presents the structure of the message that will be sent by WiseHOME to WiseCOOP as a request for information that will be provided by WiseCOOP and visualised in the front-end of the WiseHOME app.

**Table 5 – Structure of request message (WiseHOME requests information from WiseCOOP)**

| <i><b>NN</b></i> | <i><b>Name</b></i>  | <i><b>M/O</b></i> | <i><b>Values</b></i>                      |                             | <i><b>Description</b></i>   | <i><b>Data type of expected response</b></i> | <i><b>Unit</b></i> |
|------------------|---------------------|-------------------|---|-----------------------------|---|--|--------------------|
| <b>1</b>         | <b>"reference"</b>  | <b>M</b>          | Enumeration with available values:        | <i>USER</i>                 | <i>The value will specify whether the information hereunder refers to a single user/home or the cooperative as a whole.</i>   |  | -                  |
|                  |                     |                   |   | <i>PILOT_SITE</i>           |   |  | -                  |
| <b>2</b>         | <b>"assetKey"</b>   | <b>M</b>          | <i>Unique User/Cooperative Identifier</i> |                             | <i>SMX ID or Pilot Site ID for WiseGRID purposes</i>  |  | -                  |
| <b>3</b>         | <b>"dataType"</b>   | <b>M</b>          | Enumeration with type of requested data:  | <i>TIMESERIES</i>           | <i>Expected type of data that should be included in the response (in case of time-series or cumulative data the respective time duration will be specified by the startTime, endTime and Interval parameters)</i> |  | -                  |
|                  |                     |                   |   | <i>CUMULATIVE_DATA</i>      |   |  | -                  |
|                  |                     |                   |   | <i>REALTIME MEASUREMENT</i> |   |  | -                  |
|                  |                     |                   |   | <i>ENUMERATION</i>          |   |  | -                  |
|                  |                     |                   |   | <i>PERCENTAGE</i>           |   |  | -                  |
|                  |                     |                   |   | <i>AVERAGE</i>              |   |  | -                  |
| <b>4</b>         | <b>"metricType"</b> | <b>M</b>          | Enumeration with available types:         | <i>ENERGY_CONSUMPTION</i>   | <i>Consumption of grid imported energy for the time period specified</i>  | <i>Float</i>                                 | <i>kWh</i>         |
|                  |                     |                   |   | <i>ENERGY_COST</i>          | <i>Cost of grid-imported electricity for the specified time</i>   | <i>Float</i>                                 | <i>euro</i>        |
|                  |                     |                   |   | <i>SUPPLEMENTARY_COSTS</i>  | <i>Any costs incurred for electricity procurement beyond energy costs charged by the retailer or cooperative (e.g. roof-top PV rent or amortization)</i>  | <i>Float</i>                                 | <i>euro</i>        |

|  |  |  |  |                                  |  |                        |                                     |
|--|--|--|--|----------------------------------|--|------------------------|-------------------------------------|
|  |  |  |  | <i>POWER_MEASUREMENT</i>         | <i>Instantaneous power consumption</i>   | <i>Float</i>           | Watt                                |
|  |  |  |  | <i>CAPACITY</i>                  | <i>Nominal connection capacity</i>   | <i>Integer</i>         | Watt                                |
|  |  |  |  | <i>PV_PRODUCTION</i>             | <i>Energy generation of the PV for the specified time period</i>                   | <i>Float</i>           | kWh                                 |
|  |  |  |  | <i>SELF_CONSUMPTION</i>          | <i>Self-consumed electricity for the specified time period</i>                     | <i>Float</i>           | kWh                                 |
|  |  |  |  | <i>CO2_EMISSIONS</i>             | <i>Normalised CO2 intensity of collective electricity consumption</i>              | <i>Integer [0-100]</i> | %                                   |
|  |  |  |  | <i>GRID_FRIENDLY_CONSUMPTION</i> | <i>Friendliness of grid-imported consumption for grid</i>                          | <i>Enumeration</i>     | Red, Yellow, Green                  |
|  |  |  |  | <i>FLAT_PRICE_PER_KWH</i>        | <i>Electricity price per kWh under flat tariff scheme</i>                          | <i>Float</i>           | euro cents                          |
|  |  |  |  | <i>DYNAMIC_PRICE_PER_KWH</i>     | <i>Electricity price per kWh under dynamic tariff scheme</i>                       | <i>Float</i>           | euro cents                          |
|  |  |  |  | <i>FLAT_COST</i>                 | <i>Cost of consumed electricity for specified time period under flat tariff</i>    | <i>Float</i>           | euro                                |
|  |  |  |  | <i>DYNAMIC_COST</i>              | <i>Cost of consumed electricity for specified time period under dynamic tariff</i> | <i>Float</i>           | euro                                |
|  |  |  |  | <i>BATTERY_SOC</i>               | <i>Battery state of charge</i>   | <i>Integer [0-100]</i> | %                                   |
|  |  |  |  | <i>BATTERY_CHARGE_AVAILABLE</i>  | <i>Instantaneous available charge in battery</i>                                   | <i>Float</i>           | Watt                                |
|  |  |  |  | <i>BATTERY_CHARGING_STATUS</i>   | <i>Operational mode of the battery</i>   | <i>Enumeration</i>     | Disconnected<br>Connected<br>Charge |

|   |             |   |  |                   |   |             |  |
|---|-------------|---|--|-------------------|---|-------------|--|
|   |             |   |  |                   |   |             | Discharge<br>Standby<br>Error<br>Busy<br>Islanding |
|   |             |   |  | ASSETKEY_VALIDITY | Validity of supplied assetKey, whether it exists in the WiseCOOP DB                           | Enumeration | Valid, Invalid                                     |
| 5 | "startTime" | O | if <b>NULL</b> , last available data must be sent. |                   | Timestamp specifying the start time in case a cumulative amount or a time-series is requested | Timestamp   | -  |
| 6 | "endTime"   | O | if <b>NULL</b> , equals to current time (now)      |                   | Timestamp specifying the end time in case a cumulative amount or a time-series is requested   | Timestamp   | -  |
| 7 | "Interval"  | O | Enumeration with available values:                 | 15 MIN            | Enumeration specifying the time interval required when a time-series is requested             |             | -  |
|   |             |   |  | 6 HOURS           |   |             | -  |
|   |             |   |  | DAY               |   |             | -  |
|   |             |   |  | WEEK              |   |             | -  |

A few clarifications follow:

- The column M/O specifies whether a field is mandatory or optional. Optional fields will be included in the request message only when appropriate. More specifically, the optional fields specify a time duration and a sampling interval. So they are necessary when the requested information is a time-series or a cumulative value only.
- Time-series of energy consumption and generation or cost/price information is expected to include only the respective values within the specified interval, not the cumulative progression (hence, the evolution does not have to be monotonically increasing).
- The field "reference" dictates whether the requested energy related information (e.g. consumption, generation) is that of the individual home or of the entire cooperative.

- The field “assetKey” uniquely indicates which home or cooperative information is requested. In case of homes, the assetKey will be the SMX ID. In case of pilot site, the assetKey will take one of the following values, ENERCOOP, ECOPOWER, HEDNO\_KYTH, HEDNO\_MES, TERNI.
- The field “datatype” specifies the desired data format. Some information can be delivered as single values (cumulative\_data) accumulating many values or can be delivered as time-series showing the detailed evolution of the value of the respective metric. Datatype clarifies what exactly is requested by WiseHOME in order to create the visualisation that the user has asked for.
- Some parameters – such as *CO2\_EMISSIONS* & *GRID\_FRIENDLY\_CONSUMPTION* – are provisionally specified here in terms of measurement unit and data type. Their calculation method is not clear and must be defined by the project pilot partners and provided to the WiseCOOP developers in order to comply with the aforementioned specifications.
- The field “assetValidity” is used whenever a WiseHOME user registers in order to validate the provided assetKey. Whenever a new user wishes to become a user of the WiseHOME, his electricity retailer and operator of the corresponding WiseCOOP instance should provide him with two data elements: i) the appropriate URL for the WiseHOME instance that applies to the specific retailer, and ii) the assetKey of the user which is a unique identifier of his home connection to the electricity grid. When registering on the WiseHOME app, the user will be asked to provide the assetKey, the corresponding retailer, a username and a password. Optionally, he can also provide his e-mail address. In order to establish whether the user is a valid one, WiseHOME must validate that the provided assetKey exists in the database of the respective WiseCOOP instance. So, a message will be sent for this purpose.
- When this message is wrongly structured or WiseCOOP cannot decode it properly, WiseCOOP will respond with a message with “ERROR” in the MessageType field.

#### 4.3.3 Structure of notification message

This sub-section outlines the structure of the messages that are expected from WiseCOOP in order to create notifications to the users. The WiseHOME app is responsible for managing the relationship between the app users and the assetKey (meter on the electricity network). As a result, WiseCOOP is expected to provide the notification recipient in one of the two following manners: i) the cooperative / retailer, in which case all the customers of the retailer will receive the notifications, ii) a specific assetKey – which implies a specific building (home or tertiary), in which cases all the users who have registered accounts linked with this building/assetKey will receive the notification.

Table 6 – Structure of notification message from WiseCOOP to WiseHOME

| <i>NN</i> | <i>Name</i>    | <i>M/O</i> | <i>Values</i>                                  | <i>Description</i>   | <i>Data type of expected response</i> | <i>Unit</i> |
|-----------|----------------|------------|--|--|---------------------------------------|-------------|
| 1         | "reference"    | M          | Enumeration with available values: <i>USER</i> |  | String                                | -           |
|           |                |            | <i>PILOT_SITE</i>                              |  |                                       | -           |
| 2         | "assetKey"     | M          | Unique User/Cooperative Identifier             | assetKey or Pilot Site ID  | String                                | -           |
| 3         | "notification" | M          | JSON message                                   | JSON containing the notification fields, including title, body and type. (more details follow) | String                                |             |

#### 4.3.4 Structure of message to update WiseCOOP on residential DER systems

Table 7 – Structure of message to update WiseCOOP about the availability and status of residential DER devices

| <i>NN</i> | <i>Name</i> | <i>M/O</i> | <i>Values</i>                                  | <i>Description</i>  | <i>Data type of expected response</i> | <i>Unit</i> |
|-----------|-------------|------------|--|---|---------------------------------------|-------------|
| 1         | "reference" | M          | Enumeration with available values: <i>USER</i> | This message originates from the home, hence only the option <i>USER</i> makes sense <sup>1</sup> . | String                                | -           |
|           |             |            |  |   |                                       | -           |
| 2         | "assetKey"  | M          | Unique User                                    | assetKey  | String                                | -           |

<sup>1</sup> The structure of the message is intentionally kept similar to the structure of the other messages to make the software implementation more modular. In the case of this specific message – that goes from the home/WiseHOME to the WiseCOOP tool – the “reference” enumeration would contain a single option, since each home would inform the corresponding WiseCOOP instance of its devices.

|   |                             |   |              |  |        |  |
|---|-----------------------------|---|--------------|--|--------|--|
| 3 | "residentialDerInformation" | M | JSON message | JSON containing information about the residential DER systems. (more details follow) | String |  |
|---|-----------------------------|---|--------------|--|--------|--|

This message will be communicated to WiseCOOP via a different queue (to the one communicating requests for energy data). The message will not include the message preamble specified in Section 4.3.1.

## 4.4 WG IOP INTEGRATION

The messages described above will be exchanged via the WG IOP as JSON messages. The exact configuration of the IOP in terms of topics and virtual hosts will define the specific integration aspects. In any case, the exchanged messages include all the necessary information to facilitate end-to-end communication. The following sub-sections provide samples of the request and response messages.

### 4.5 SAMPLE REQUEST MESSAGE

The following message is an example of a WiseHOME instance with ID ""001DK1004" asking the WiseCOOP instance of "ECOPOWER" for the following information:

- The time-series of energy consumption of the home with assetKey "DK1004" between 10:45 and 11:15 on 18/7/2017 in intervals of 15 minutes; and
- The cumulative energy cost of the same home from 10:45 on 18/7/2018 until today.

```
{
  "header": {
    "Sender": "001DK1004",
    "Recipient": "ECOPOWER",
    "conversationID": "ECPDK1004001",
    "messageType": "REQUEST"
  },
  "body": [
    {
      "reference": "USER",
      "assetKey": "DK1004",
      "dataType": "TIMESERIES",
      "metricType": "ENERGY_CONSUMPTION",
      "startTime": "2017-07-18T10:45:01.898Z",
      "endTime": "2017-07-18T11:15:01.842Z",
      "sampleTime": "15 MIN"
    },
    {
      "reference": "USER",
      "assetKey": "DK1004",
      "dataType": "CUMULATIVE_DATA",
      "metricType": "ENERGY_COST",
      "startTime": "2017-07-18T10:45:01.898Z",
    }
  ]
}
```

Figure 4 - Example of request message

#### 4.6 SAMPLE RESPONSE MESSAGE

The following text box illustrates the associated response to the request above. The Sender and Recipient

```
{
  "header": {
    "Sender": "ECOPOWER",
    "Recipient": "001DK1004",
    "conversationID": "ECPDK1004",
    "messageType": "RESPONSE"
  },
  "body": [
    {
      "reference": "USER",
      "assetKey": "DK1004",
      "dataType": "TIMESERIES",
      "metricType": "ENERGY_CONSUMPTION",
      "endTime": "2017-07-18T11:15:01.842Z",
      "sampleTime": "15 MIN",
      "metricTimeseries": [
        {
          "value": 1.49,
          "timestamp": "2017-07-18T10:45:01.908Z"
        },
        {
          "value": 0.44,
          "timestamp": "2017-07-18T11:00:01.833Z"
        },
        {
          "value": 2.07,
          "timestamp": "2017-07-18T11:15:01.842Z"
        }
      ]
    },
    {
      "reference": "USER",
      "assetKey": "DK1004",
      "dataType": "CUMULATIVE_DATA",
      "metricType": "ENERGY_COST",
      "startTime": "2017-07-18T10:45:01.898Z",
      "value": 250.10
    }
  ]
}
```

**Figure 5 - Example of response message (to the request illustrated in Figure 4)**

IDs have been swapped and the conversationID remains the same to allow WiseHOME to associate the two messages.



#### 4.7 SAMPLE NOTIFICATION MESSAGE

The following textbox indicates the structure of the message expected from WiseCOOP in order to send a

```
{
  "reference": "USER",
  "assetkey": "testkey",
  "notification": {
    "title": "Wishome App",
    "body": "Hello $Name, electricity prices will peak
between 18.00 and 21.00 today. Be prepared!"
    "type": "Warning"
  }
}
```

**Figure 6 - Example of notification message**

notification to the appropriate customers. In the case of this example, the notification will be sent to the WiseHOME app users whose home/smart meter identifier has the value *testKey*. The notification body has a title, a body and a type. The type is an enumeration that can take one of three possible values {Alert, Info, Warning}. The data type of the *type* field must be string.

The wildcard *\$Name* can be used in order to personalise the message by adding the username of the recipient. When WiseCOOP structures the message body with *\$Name* included, the application of the WiseHOME application will replace *\$Name* with the username of the user receiving the notification. Different users in the same building will receive messages with their names correctly replace. A single user will see the same message (with his name) across all the devices with which he has subscribed on the WiseHOME app.

#### 4.8 SAMPLE MESSAGE TO INFORM WISECOOP ABOUT RESIDENTIAL DEVICES

The following textbox provides an example of a JSON message that comprises the payload of the message structure outlined in Section 4.3.4. Its purpose is to convey to WiseCOOP the information about the residential assets and the user's wish to opt the assets in for automated control by a third-party (the retailer).

```
{
  "reference": "USER",
  "assetKey": "DK1004",
  "residentialDerInformation":
    {
      "assetConfigurationID": 110,
      "assetConfigurationKey": "DK1004",
      "assetConfigurationPvAvail": 1,
      "assetConfigurationPvOptin": 0,
      "assetConfigurationPvNominalP": "10kWhp",
      "assetConfigurationInvVendor": "SMA",
      "assetConfigurationInvModel": "Power+",
      "assetConfigurationBattAvail": 1,
      "assetConfigurationBattOptin": 1,
      "assetConfigurationBattVendor": "VARTA",
      "assetConfigurationBattModel": "element"
    }
}
```

**Figure 7 - Example of message to inform WiseCOOP about device availability and information in specific home**

#### 4.9 INFORMATION STORAGE

The WiseHOME application will rely on other WiseGRID tools for the information to be visualised. Most information will be available by WiseCOOP, especially information that relies of metering data for its calculation. WG STaaS/VPP may also be involved – as it directly monitors and controls all batteries – in order to provide information about the status and activity of any battery installed in the home. In all cases, the information exchanged will comply with the format specified in Chapter 4.

Beyond temporary caching for visualization purposes, energy-related information will not be stored in a locally deployed database. The only information which will be managed by the WiseHOME is the credentials of the user – username & password; the cooperative or pilot site where the user belongs; his SMX ID – or other unique ID such as the home connection point code - as well as configuration information regarding available equipment in the home.

## 5 User Manual

### 5.1 GETTING STARTED

Any citizen that wants to use the WiseHOME app must be a customer of an electricity retailer or cooperative that uses the WiseCOOP product to manage its operations. The retailers/cooperative is responsible for providing to the potential user the necessary information in order to successfully register to the WiseHOME app. This information includes the URL of the retailer-specific instance of the WiseHOME app, the assetKey (the unique customer identifier in the retailer portfolio) and the name of the retailer/cooperative which can be recognised by the WiseHOME app. The process and method of obtaining this information has been specified in Deliverable 7.2 “WiseCOOP and WiseCORP Apps implementation and lab-testing”.

Based on these three information elements the user can initiate the registration process by typing the URL in a browser running on a device connected to the internet, as illustrated below:

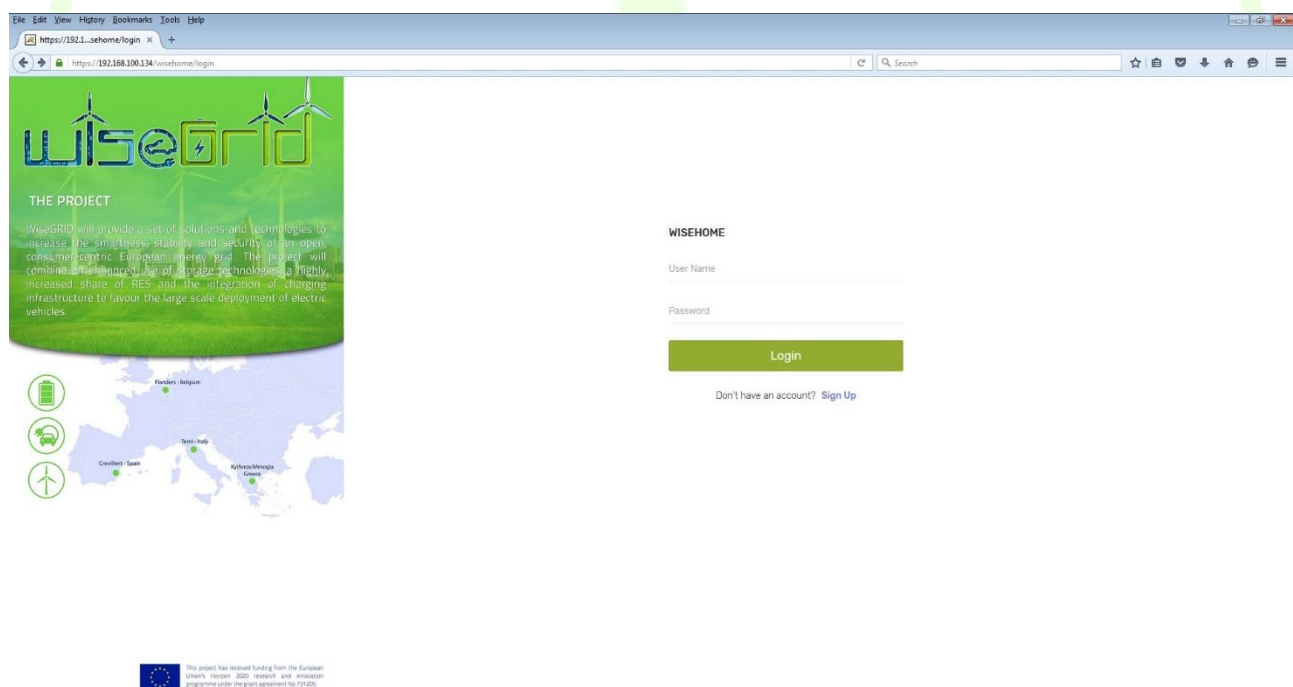
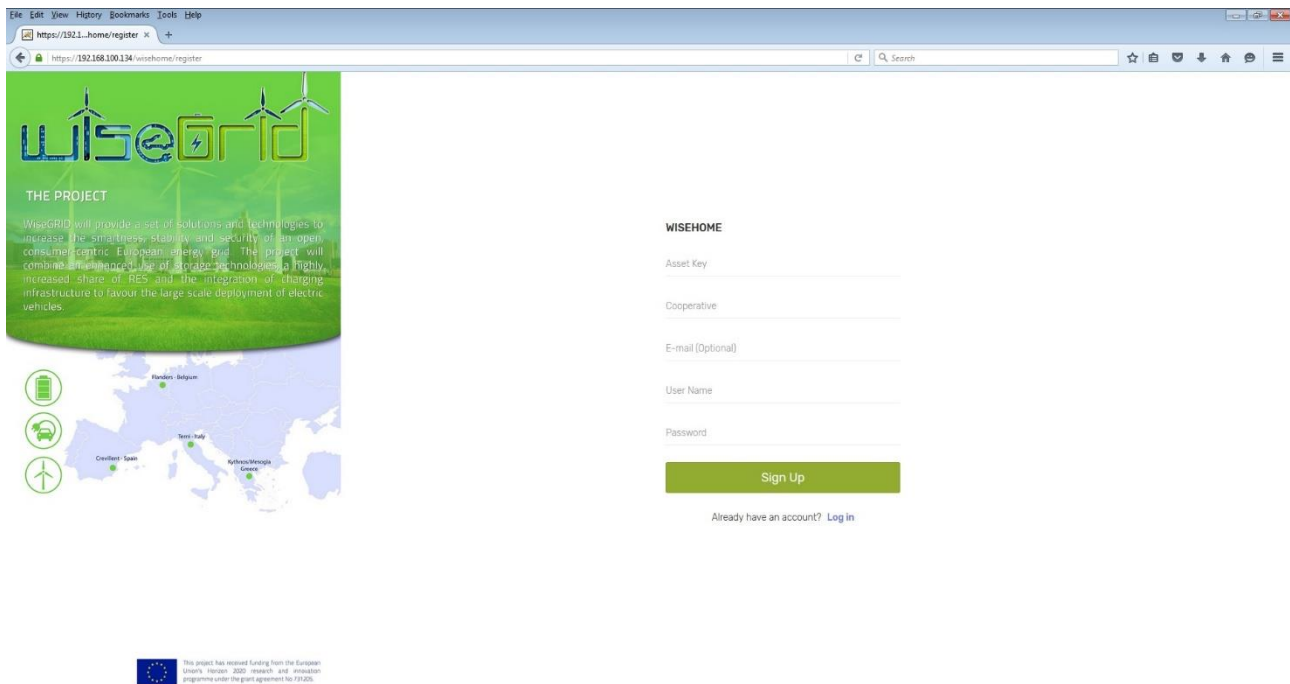


Figure 8 - Log in page of WiseHOME app

The first screen by defaults points to the log in screen, which is much more commonly needed in typical usage scenarios. To register the user must click on the “Sign up” link at the bottom of the screen. He is then confronted with the following page, where he should fill in the required information.



**WiseGRID**

**THE PROJECT**

WiseGRID will provide a set of solutions and technologies to increase the smartness, stability and security of an open, consumer-centric European energy grid. The project will combine an advanced use of storage technologies, a highly increased share of RES and the integration of charging infrastructure to favour the large scale deployment of electric vehicles.

Locations: Randen, Belgium; Terni, Italy; Ciudad Real, Spain; Kythnos/Micropolis, Greece.

**WISEHOME**

Asset Key:

Cooperative:

E-mail (Optional):

User Name:

Password:

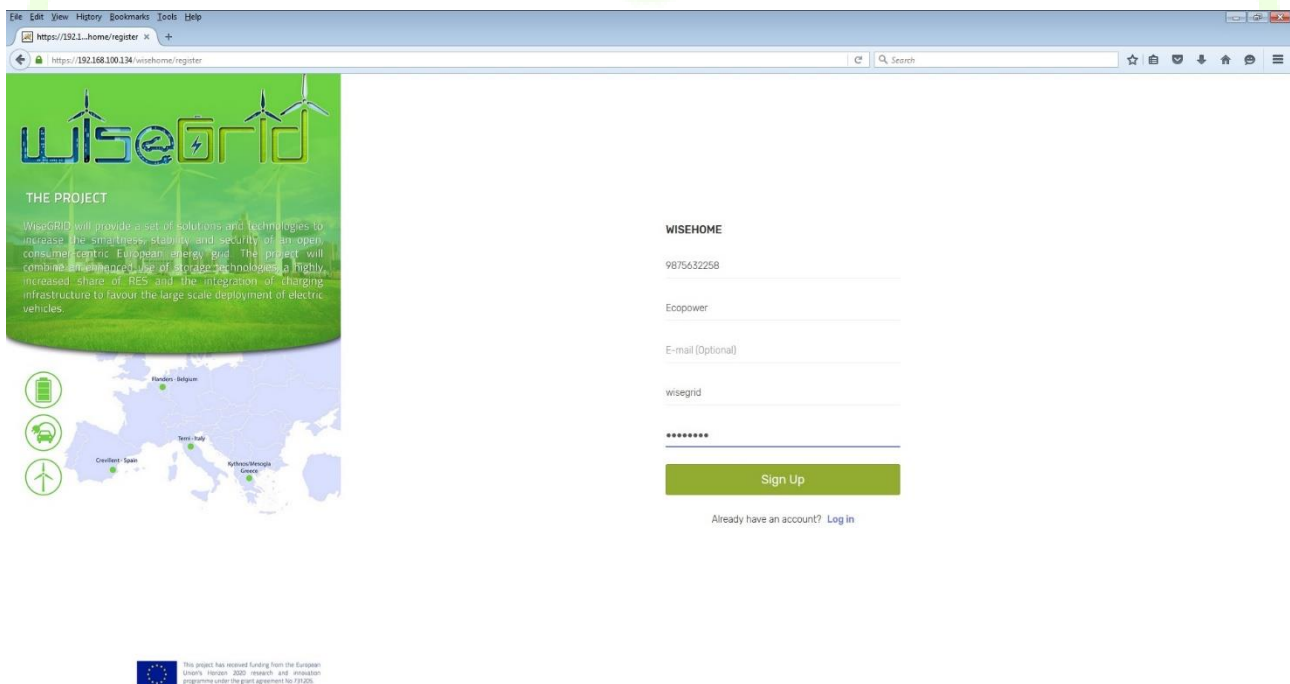
**Sign Up**

Already have an account? [Log In](#)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 737205.

**Figure 9 - Registration page**

The user fills in the required information and optionally his e-mail address.



**WiseGRID**

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Locations: Randen, Belgium; Terni, Italy; Ciudad Real, Spain; Kythnos/Micropolis, Greece.

**WISEHOME**

9875632258

Ecopower

E-mail (Optional):

wisegrid

\*\*\*\*\*

**Sign Up**

Already have an account? [Log In](#)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 737205.

**Figure 10 - Registration page filled in with sample information**

Once the information is filled in and the user clicks on the “Sign Up” button, the WiseHOME app checks the validity of the required information (assetKey, cooperative) and if this check is successful a new account is created. Then the user is led back to the log in screen.

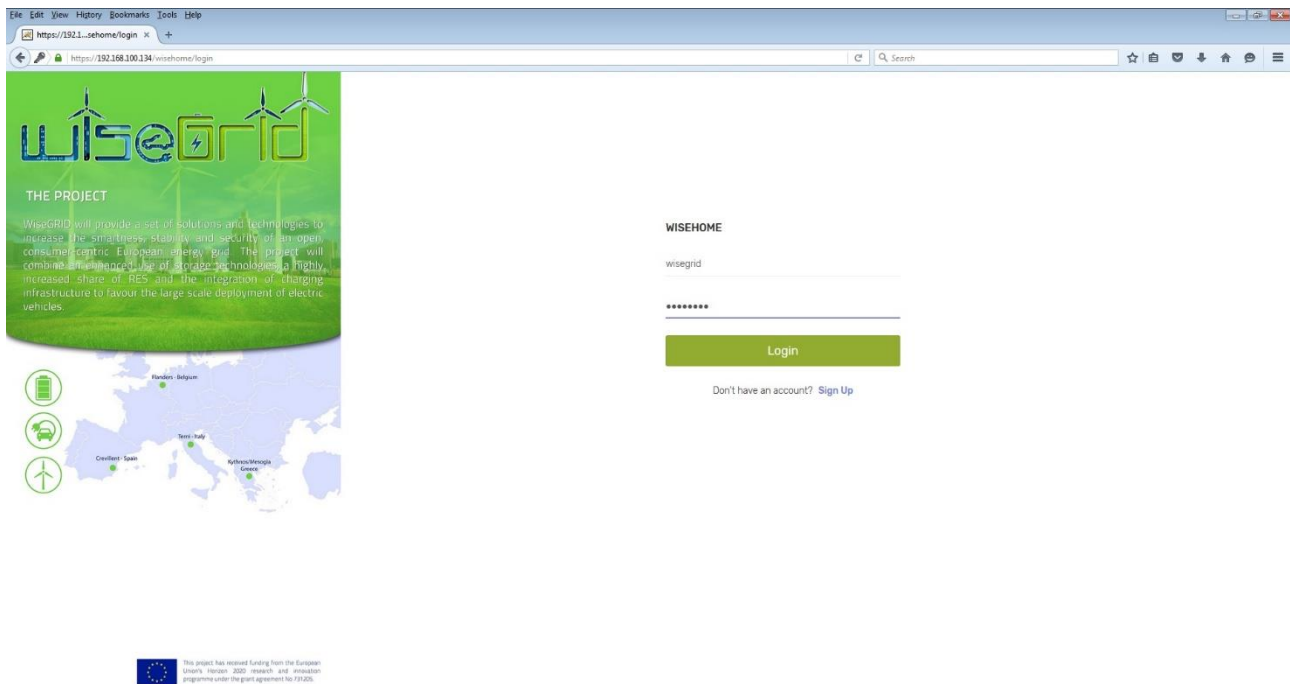


Figure 11 - Filled-in log-in page

When the user logs in the WiseHOME app for the first time, he is asked to provide some information about the devices available in the home, namely batteries and PV installations. The information to be provided includes whether such devices are available, whether the user opts them in for remote control by the operator of the WiseCOOP application as well as information about capacities and vendors/models<sup>2</sup>. This information needs to be provided only once per home to the WiseHOME app. If another user registers with the same assetKey (which implies the same household) the configuration screen will not appear.

<sup>2</sup> It is important to note that at this stage this information is not actively used by the WiseCOOP operator, mainly due to the lack of infrastructure for remote control of the devices. This feature has been added to WiseHOME to enable future Demand Response related use cases where the retailer/cooperative may wish to engage in more complex commercial agreements with their customers in order to leverage residential assets for portfolio balancing.

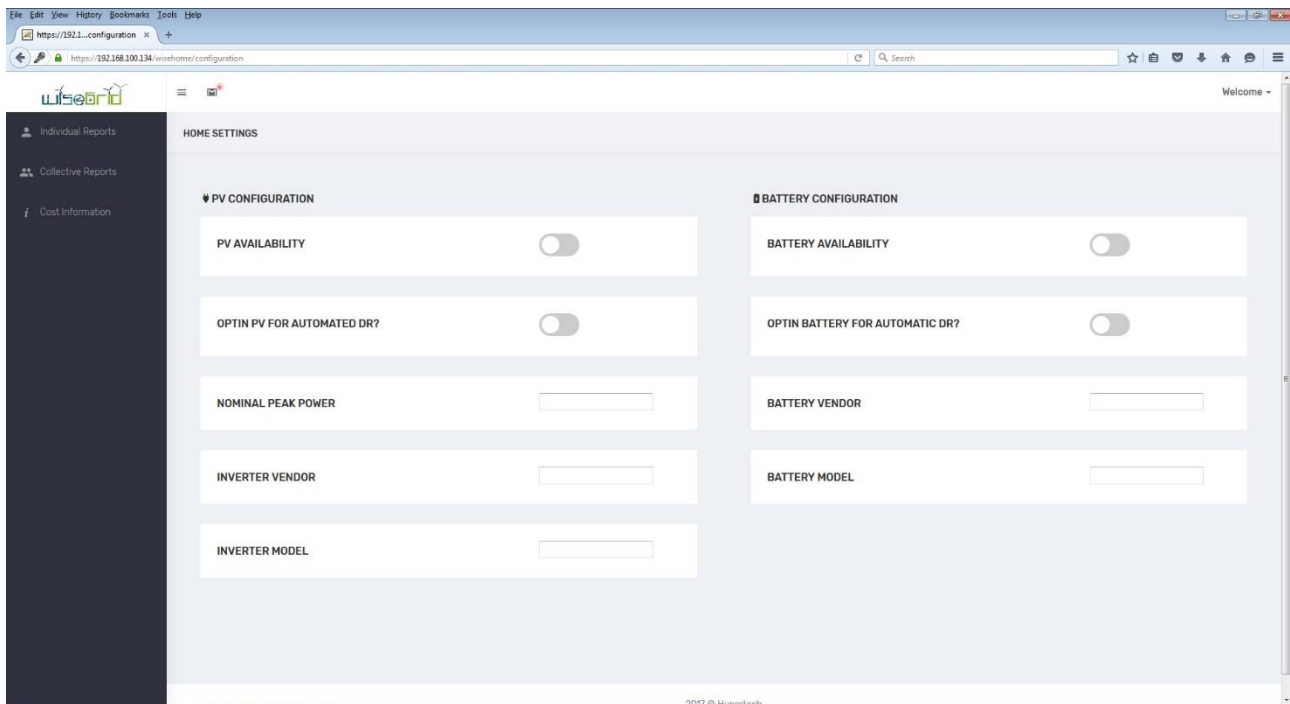


Figure 12 - Residential device configuration page

## 5.2 WISEHOME APP STRUCTURE

The main contents of the web app are split into three distinct screens or dashboards, including:

- Individual reports: this dashboard displays information about the performance of the user's home in terms of energy;
- Collective reports: this dashboard visualises information about the collective performance of the group comprising the portfolio of the retailer or the members of the cooperative;
- Cost information: this screen illustrates useful information about the electricity price and the energy cost for the particular household.

In order to provide useful information to the user, a lot of the information provided in the graphs is comparative against past reference periods of the same home. Given the seasonality of energy patterns as well as the diverse requirements of individual users, WiseHOME allows the user to define the reference period of choice. There are four available options: day, week, month and year. This reference period is selected from 4 buttons on the top right of the main user interface screen.

### 5.2.1.1 Tab 1: Individual reports

The screen showing information about the user's home energy performance shows a variety of metrics.

The actual power component illustrates the current instantaneous power consumption, as well as how this relates to the maximum allowable power consumption based on the existing supply contract.

The consumption pie chart shows information about the actual energy consumption of the household, compared against the consumption of a past reference period. The rightmost pie chart indicates how much of the consumed energy was imported from the grid and how much was self-generated. On the bottom half of this screen there is information about the energy cost and potential rewards from participation in demand response programs as well as information about the status of renewable and storage devices available in the home.

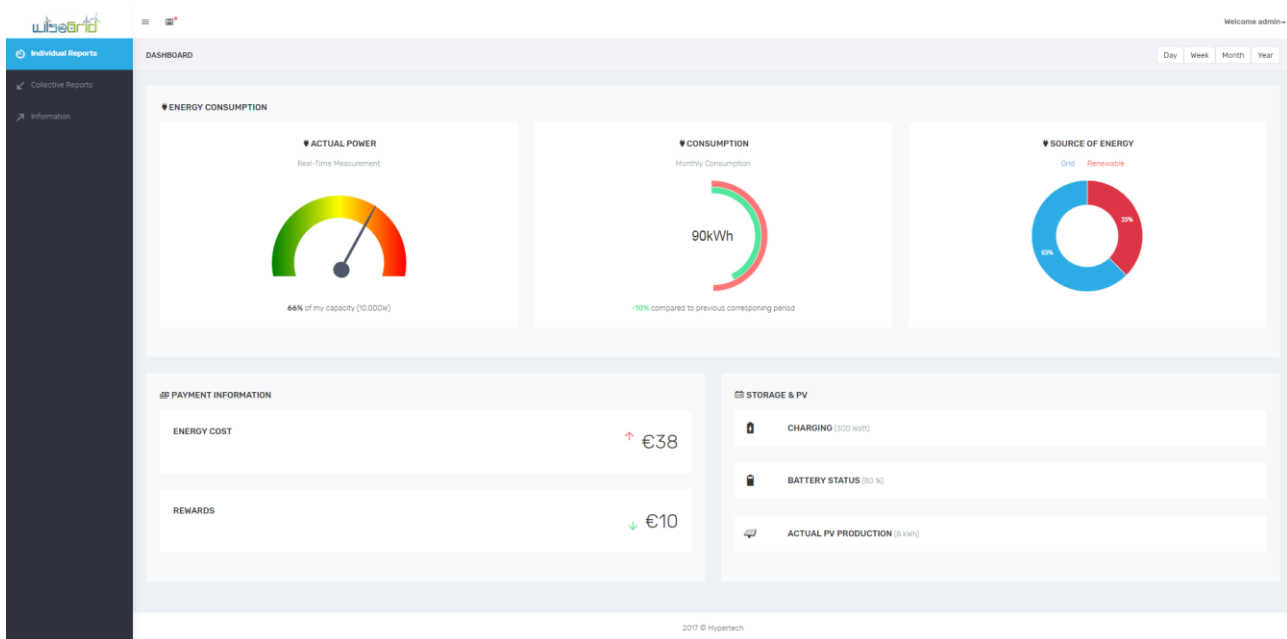


Figure 13 - Individual reports screen

The user can click on the consumption in order to drill-in and see the evolution of the household energy consumption over time for the appropriate reference period. The two lines on the diagram represents the current energy consumption and the consumption during the reference period.

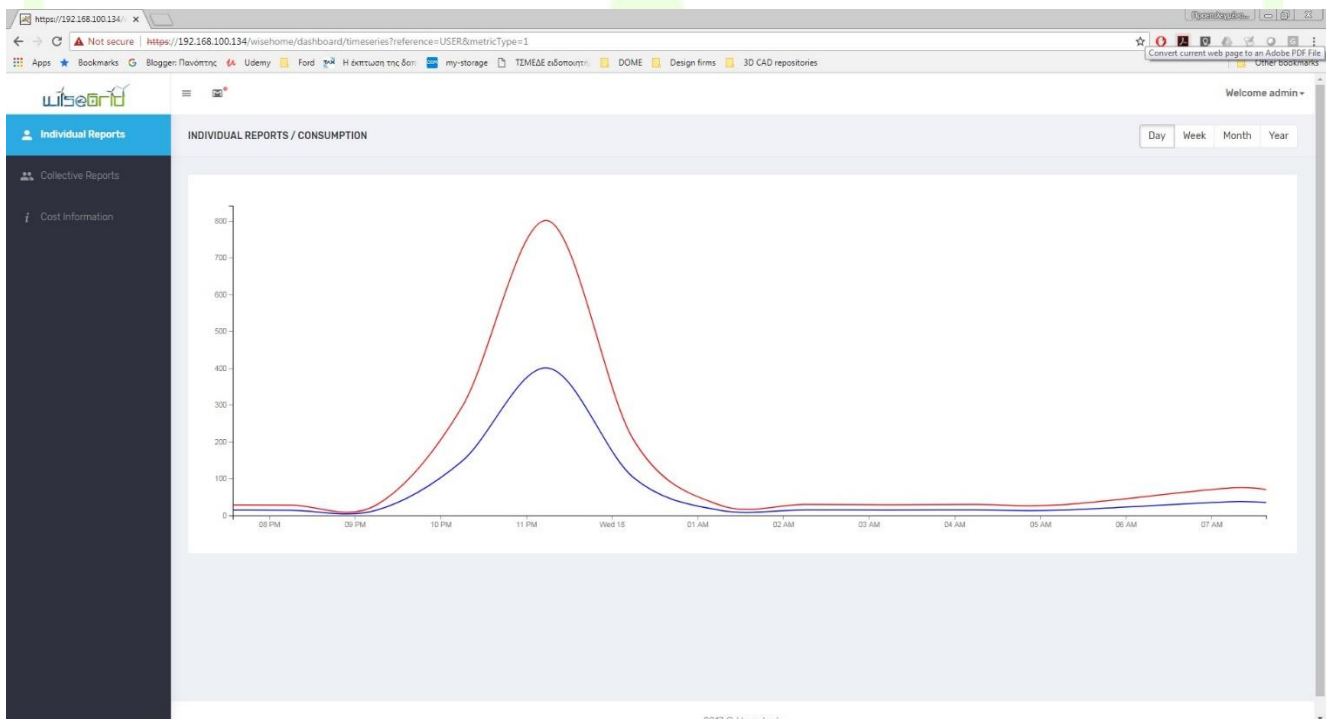


Figure 14 - Time evolution of energy consumption of household

### 5.2.1.2 Tab 2: Collective reports

The collective reports tab illustrates information about the performance of groups of energy consumers. The three graphs visualise the following:

- Local generation: the percentage of energy that was imported (and consumed) from the grid versus the percentage of consumed energy that was generated within the neighbourhood or cooperative by some renewable energy source that belongs to it;
- CO<sub>2</sub> intensity: this metric is meant to represent the carbon footprint of the energy consumed collectively and is effectively calculated using a CO<sub>2</sub> intensity factor. The more red the reading is, the more polluting are the energy sources that generated the electricity consumed. When renewable sources produce, this reading will lean toward the left/green side;
- Grid consumption: this metric depicts whether the dynamics of the collective energy consumption are aligned with the needs of the distribution grid. For instance, the grid typically has a peak in the evening of weekdays and further energy consumption at that period can stress it. A green reading on the traffic light means that the time profile of the consumption does not inflict further stress of the grid, and energy is consumed mostly at times of low overall demand. A red reading indicates that the collective consumption follows the time patterns of the overall grid demand, hence adds to the grid stress.

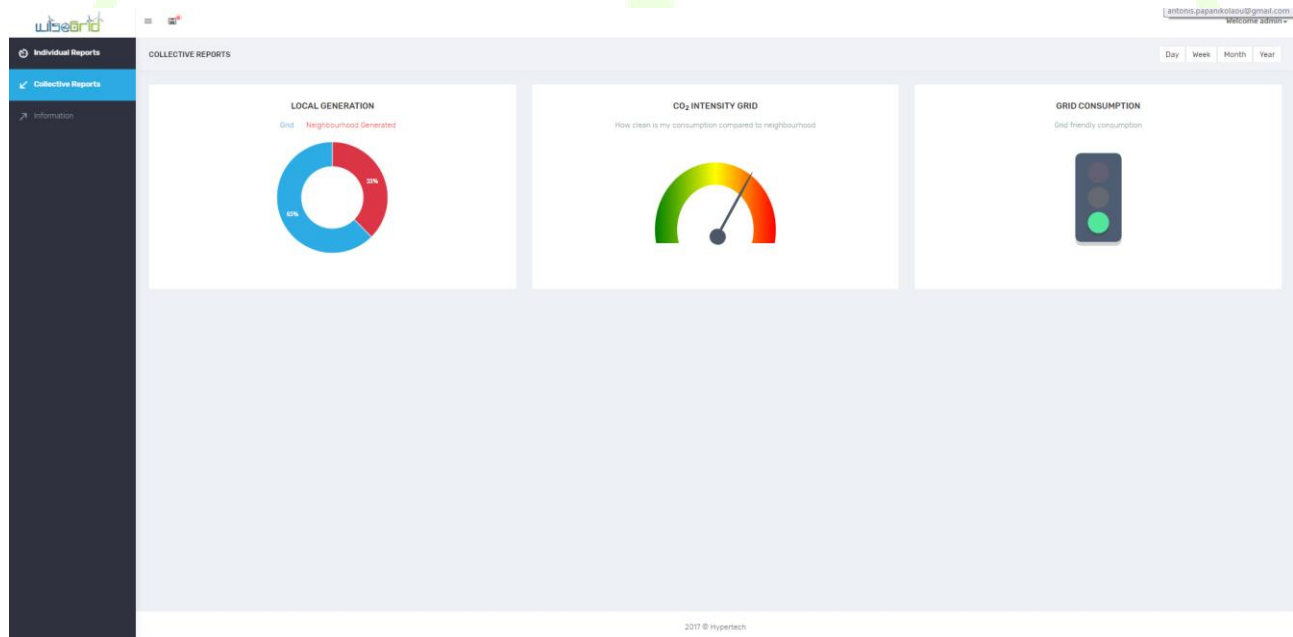
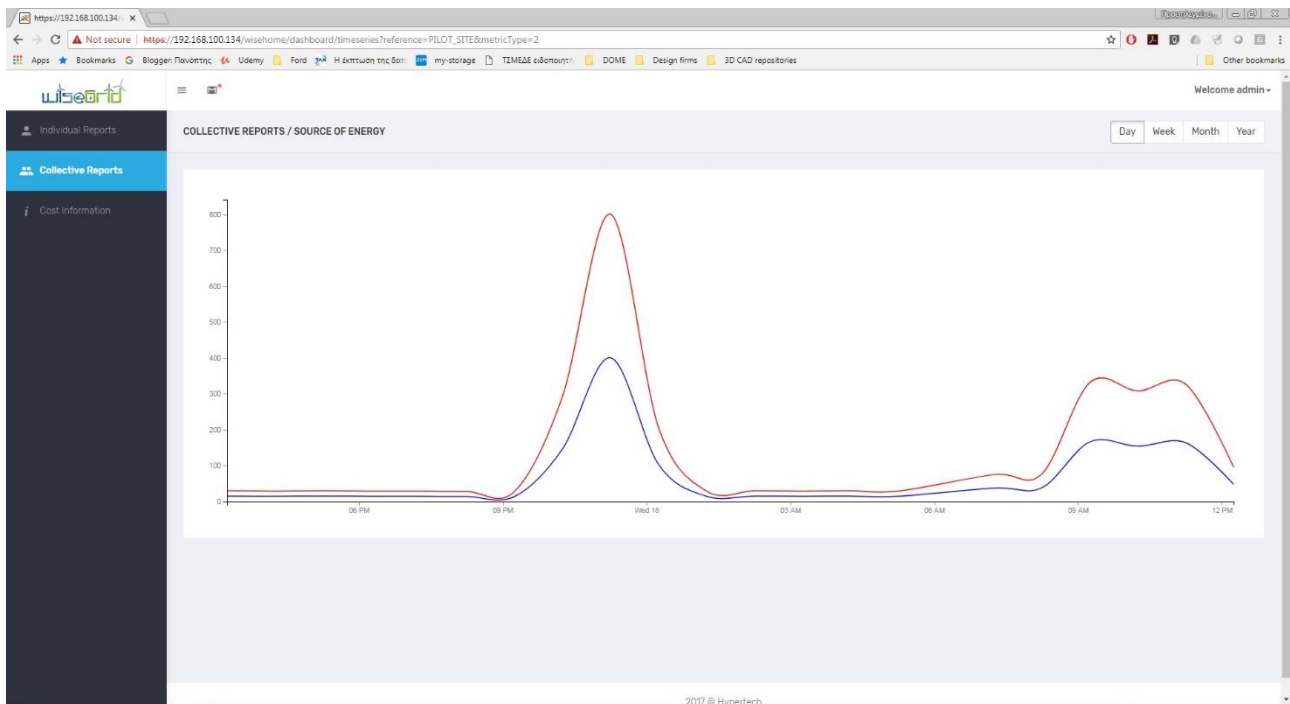


Figure 15 - Collective reports screen

The user can click on the local generation visualization in order to drill-in the time evolution of the available energy sources, namely how much electricity has been imported and consumed from the grid vs. how much electricity has been generated and self-consumed by the cooperative members collectively.





**Figure 16 - Drill-in displaying the energy source (grid imported or self-generated)**

### 5.2.1.3 Tab 3: Cost information

The purpose of the tab is twofold. On the one hand to inform the user about his energy cost in a graphical manner and by showing the evolution of cost. On the other hand, it also illustrates the impact of a dynamic tariff of the energy cost of the consumer. The figure in the left shows the dynamic electricity price, while the right figure shows the cumulative energy cost for the period of reference. The difference in total energy cost caused by the application of dynamic prices can be become evident in this manner. Furthermore, an interested user can also look into and anticipate price patterns, so as to schedule his/her energy consumption accordingly and reduce his energy costs.

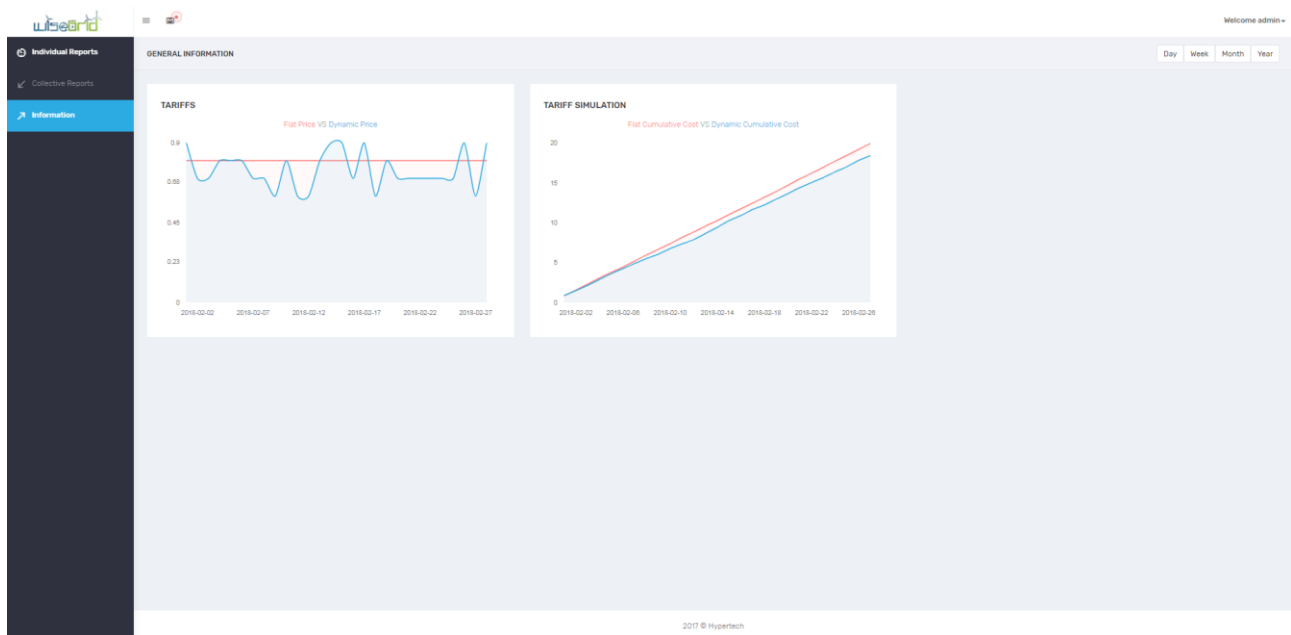


Figure 17 - Cost information screen

#### 5.2.1.4 Notifications centre

The WiseHOME app includes a notification centre which will receive messages from the WiseCOOP operator in case he wants to contact the user. The most frequent use will be the transmission of demand response requests – either as price signals or as pleas to reduce load - by the retailer or the cooperative, so that the user can anticipate and respond to very high price signals.

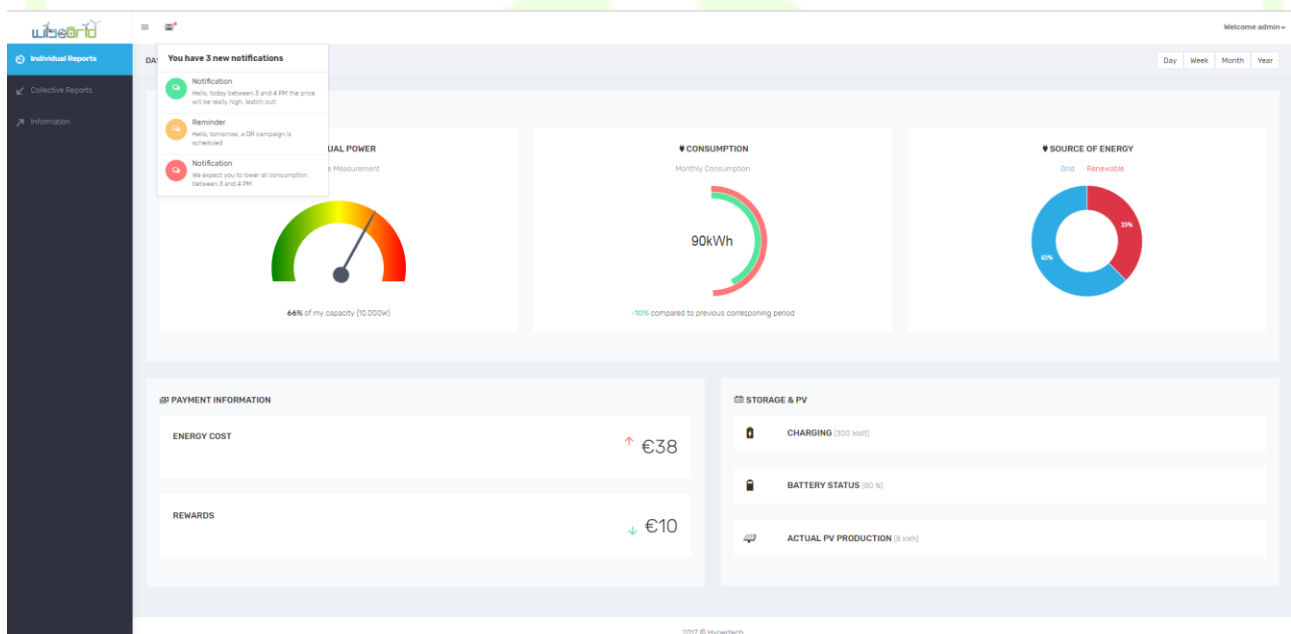


Figure 18 - Notifications centre screen

### 5.3 NOTIFICATIONS

Apart from the notifications centre, notification are also displayed as native notifications of the operating system/browser. The goal is to be able to reach the user at the appropriate times with a minimally intrusive tool even if he does not have the WiseHOME app open in his browser.

Three types of notifications can be sent to the user, which will have different icons or text formatting in order to represent different semantics on urgency or priority. These types may be instantiated as warnings, alerts and information. Alerts can be use in the case of upcoming high price signals to alert the user in advance, so that he/she can lower his/her energy consumption. Warnings can represent messages that inform the user that he/she may be close to the operational or contractual limits of his/her connection (e.g. his/her instantaneous power consumption is very close to the connection capacity). Finally, information messages can contain any kind of information that the retailer may wish to convey to the user.

Native notifications appear as shown in the Figure below (in the case of Firefox running on a Windows PC). Other browsers and operating systems have slightly different ways to visualise the notifications.

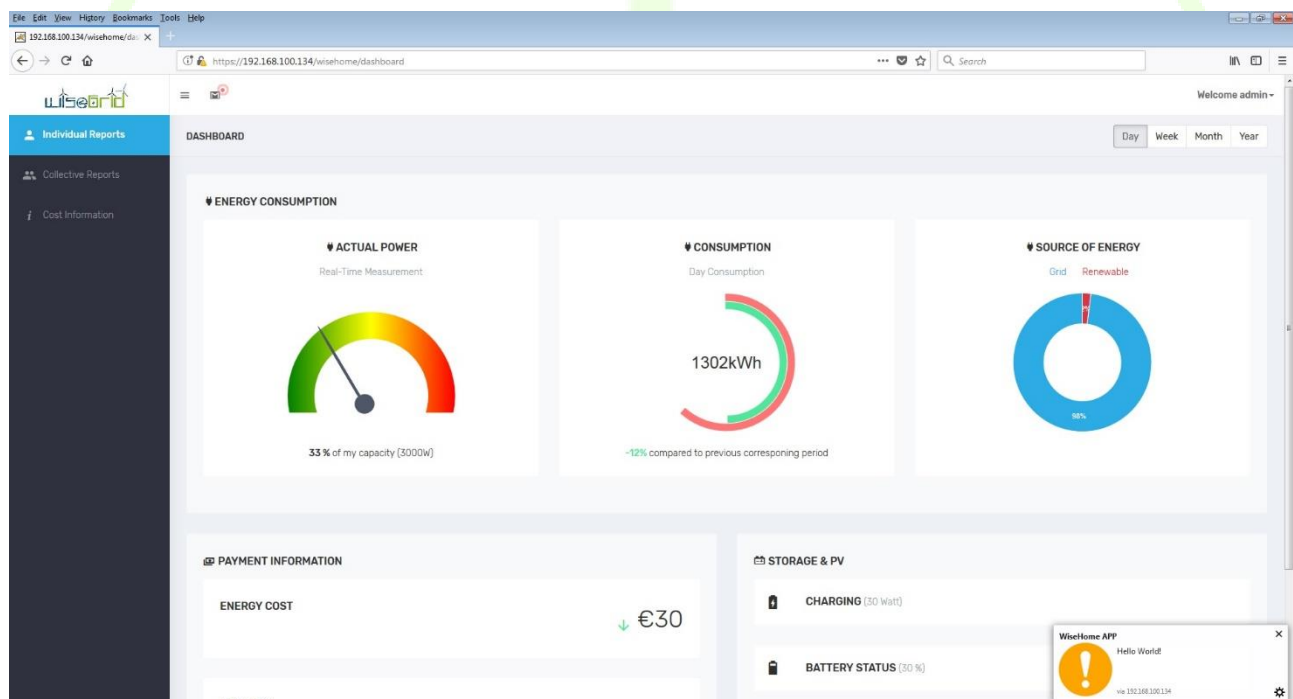


Figure 19 - Appearance of native notification on a MS-Windows PC

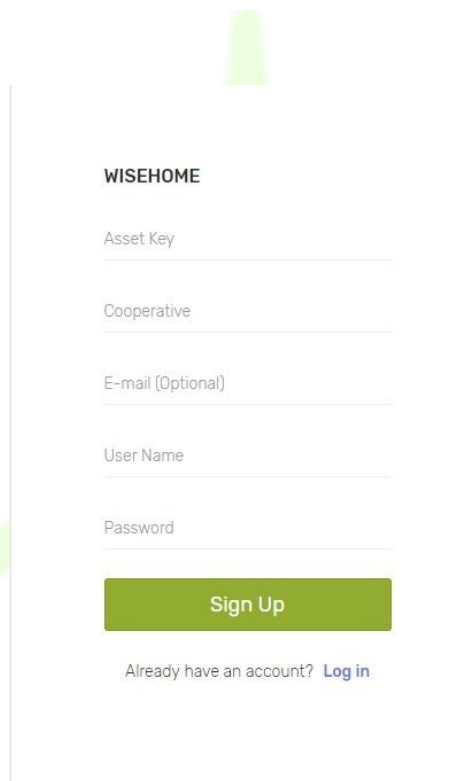
**Disclaimer: the display of native notifications requires that the user accepts their receipt. The first time that the user logs into the WiseHOME app, he will be asked whether he accepts or not the reception of notifications. If he does not, then he will only be able to see the notifications in the notifications centre of the WiseHOME app.**

## 5.4 APP RESPONSIVENESS

The design of the WiseHOME app has been performed in a fully responsive manner. This enables the user to use it from any device he has available without hampering accessibility or visibility. The following sub-sections illustrate how the WiseHOME app appears in a smartphone screen. These specific screenshots have been captured from a Pixel 2 smartphone device, but any modern smartphone should provide the user with a similar look and feel of the app. Only small deviations are expected due to potentially different screen aspect ratios and resolutions.

The various user interface elements and components (charts, diagrams, etc.) are exactly the same as previously described. Please refer to the sub-sections 5.1 and 5.2 for clarifications.

### 5.4.1 User registration

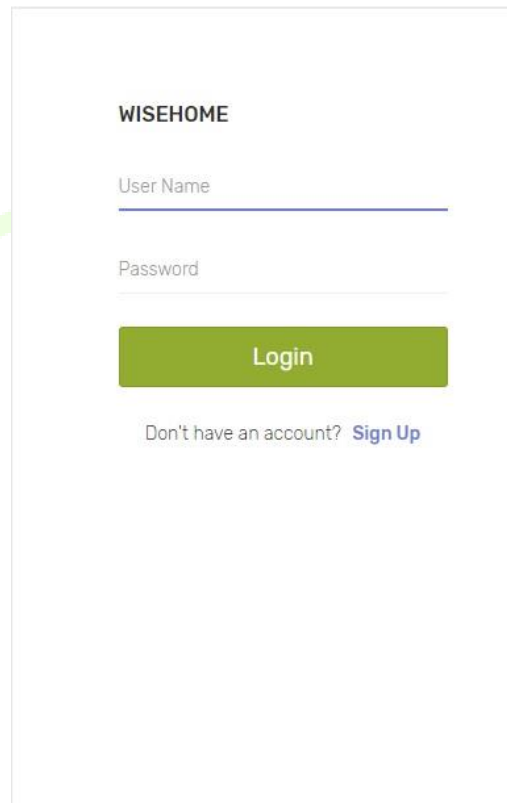


The image shows a user registration screen on a smartphone display. The screen is framed by a large, light green circular graphic. The registration form is centered and contains the following elements:

- WISEHOME** (App Name)
- Asset Key
- Cooperative
- E-mail (Optional)
- User Name
- Password
- 
- ☐ Already have an account? [Log in](#)

Figure 20 - User registration screen on smartphone display

### 5.4.2 Log in screen



**WISEHOME**

User Name

Password

**Login**

Don't have an account? [Sign Up](#)

Figure 21 - Log in screen on smartphone display

### 5.4.3 Menu

Given the limited screen size of a smartphone, the menu is not shown by default. When the user touches an icon (three horizontal lines) in the top right side of the screen, the following menu appears.

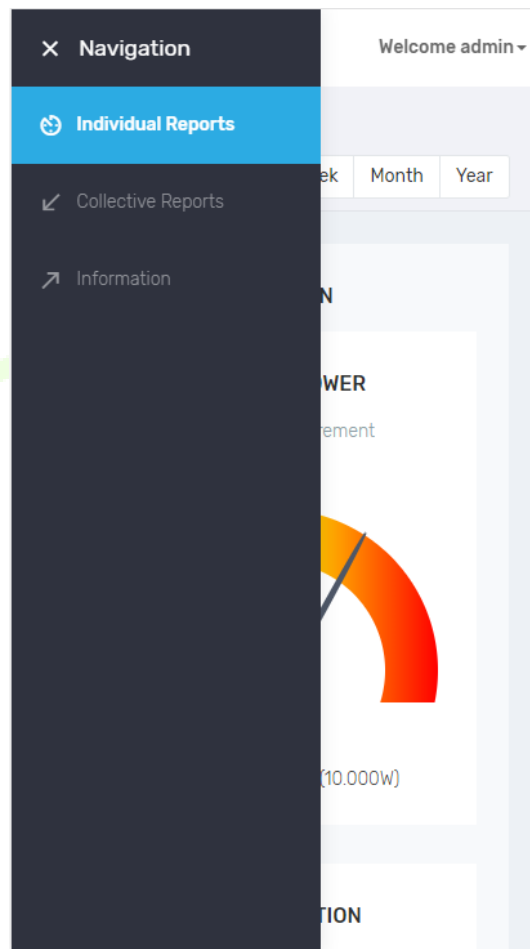


Figure 22 - App menu on smartphone display

## 5.4.4 Operation

### 5.4.4.1 Tab 1: Individual reports

The following screens correspond to the diagrams and charts explained beforehand. Multiple screen shots are provided, since the user will have to scroll down in order to see all the components.

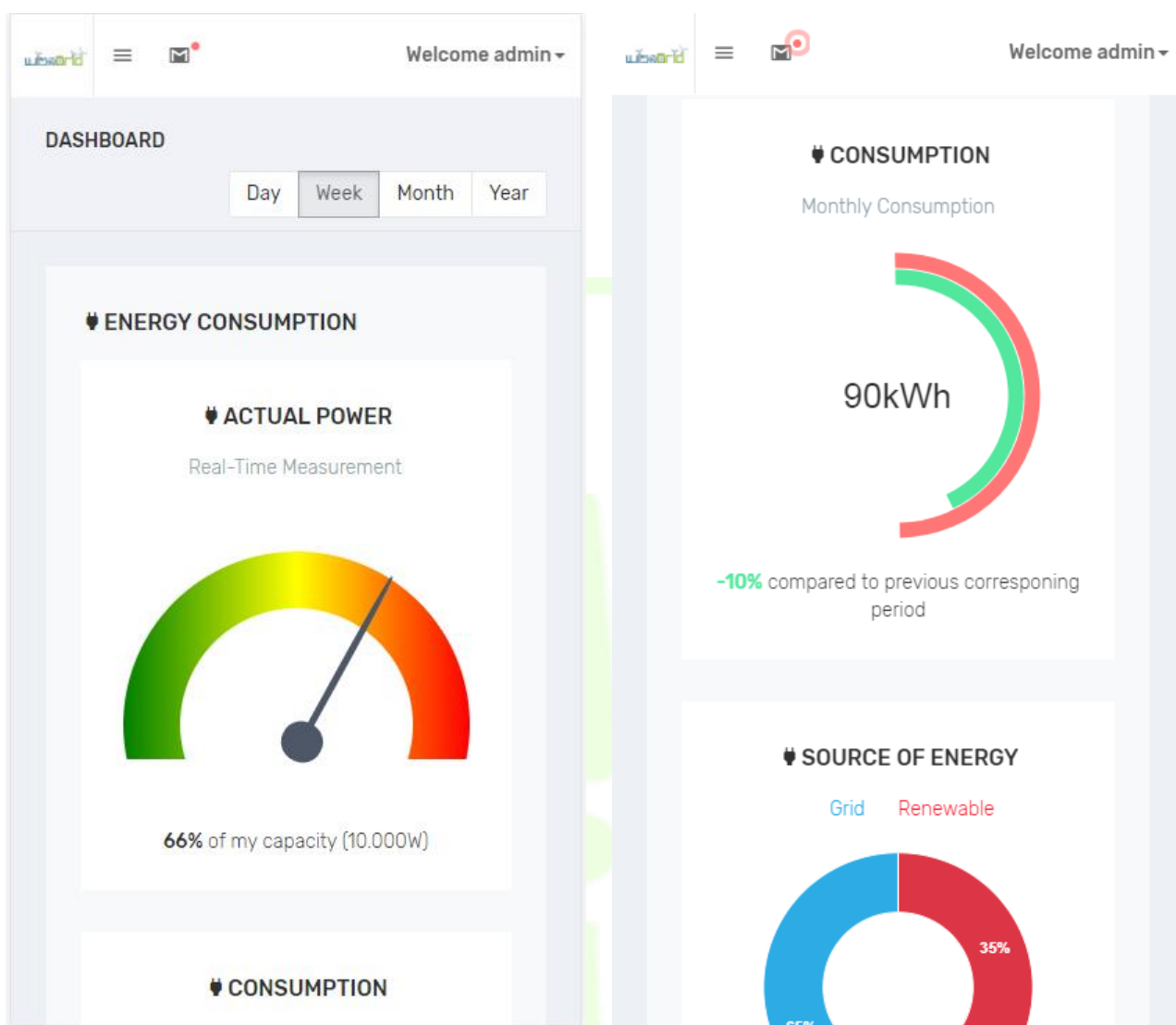


Figure 23 - Individual reports screen on smartphone display

#### 5.4.4.2 Tab 2: Collective reports

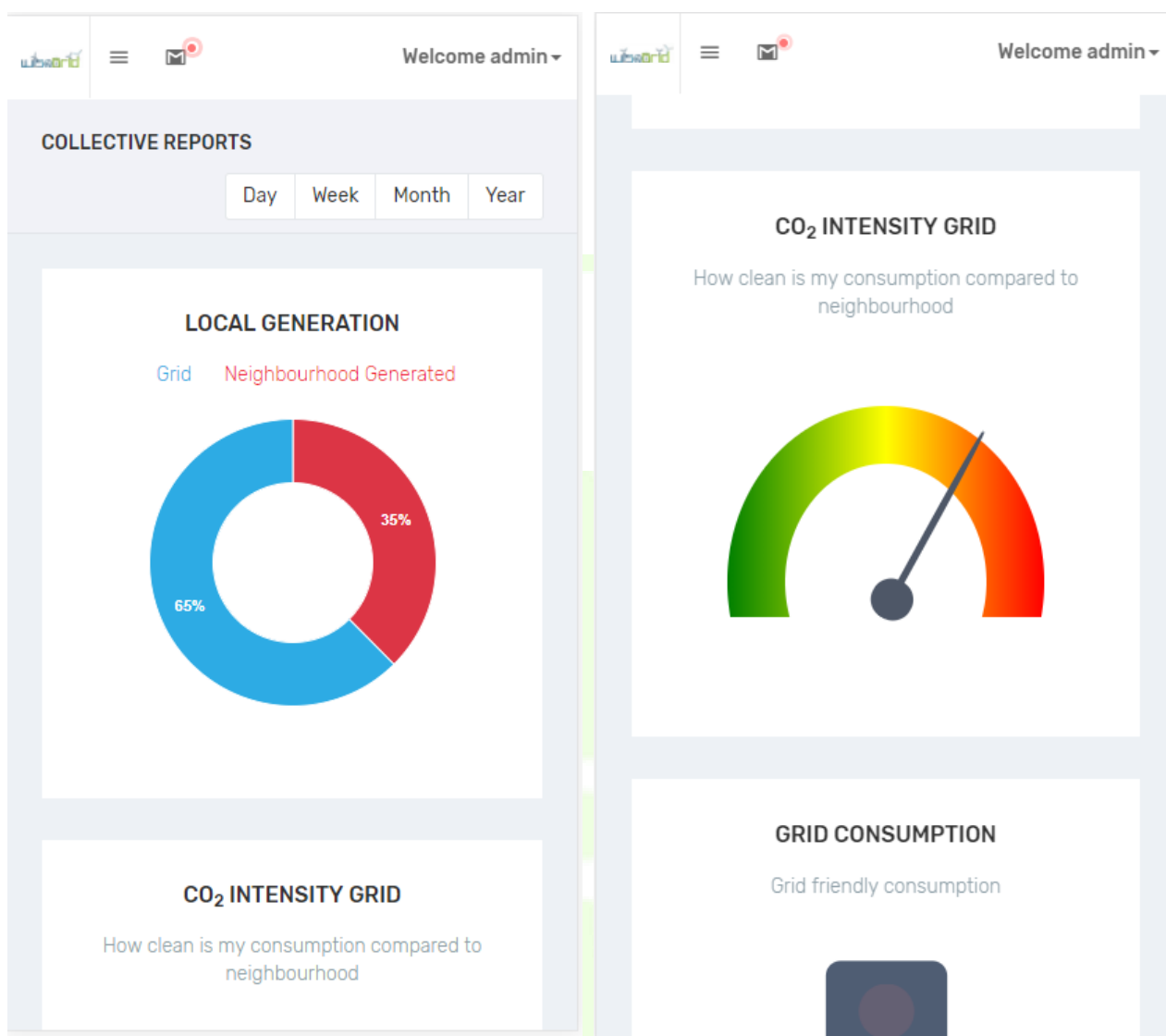


Figure 24 - Collective reports on smartphone display

#### 5.4.4.3 Tab 3: Cost information



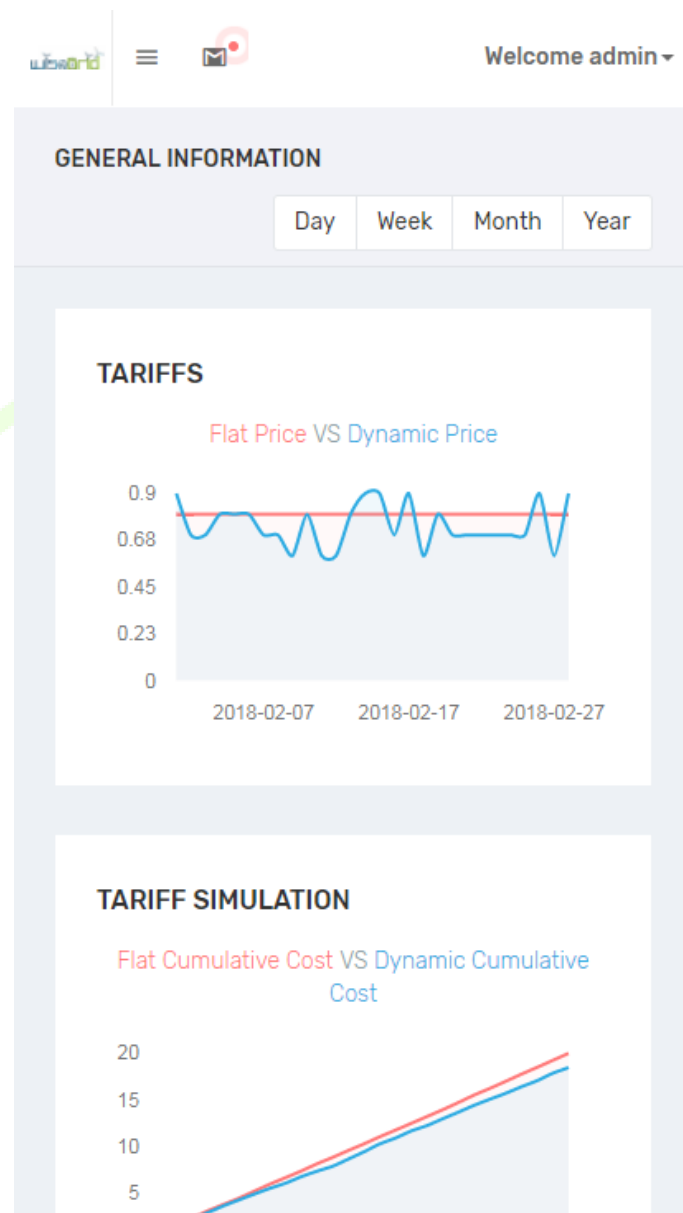


Figure 25 - Cost information on smartphone display

#### 5.4.4.4 Notifications centre

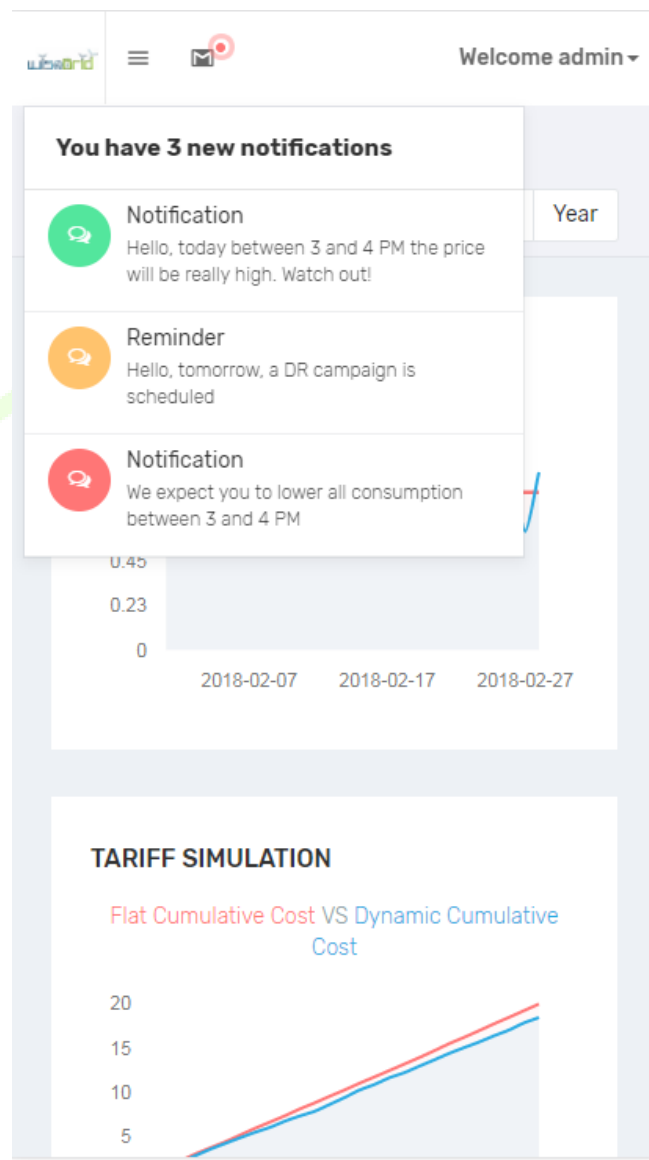


Figure 26 - Notifications centre on smartphone display

#### 5.4.4.5 Native notifications

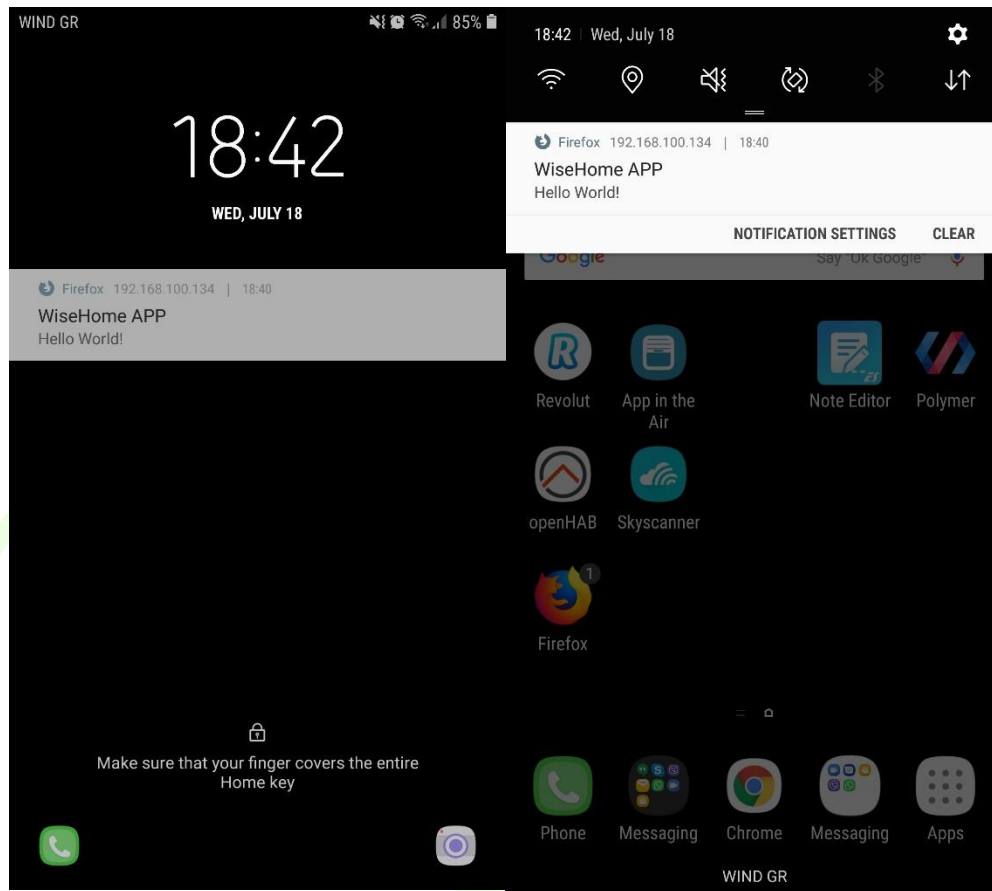


Figure 27 - Native notifications on an Android smartphone

## 5.5 COMPATIBILITY

The WiseHOME web app is compatible with all internet browsers and all operating systems. The web app has been extensively tested using the Chrome & Firefox browsers on the Windows and Android operating systems. It is compatible and should display and operate properly on any modern (& updated) internet browser and operating system.

Table 8 – Compatibility of WiseHOME app with browsers/OSs

|                        | Windows | Android | iOS | MACOS |
|------------------------|---------|---------|-----|-------|
| Chrome                 | ✓       | ✓       | ✓   | ✓     |
| Firefox                | ✓       | ✓       | ✓   | ✓     |
| Safari                 | ✓       | ✓       | ✓   | ✓     |
| Internet Explorer/Edge | ✓       | ✓       | ✓   | ✓     |

The only potential compatibility issue concerns the reception of notifications, which are treated in a different manner per device, operating system and browser. In all cases, the user must respond positively to a prompt he will receive regarding whether or not he wants to receive notifications.

**Table 9 – Compatibility of WiseHOME app native notifications with browsers/OSs**

|                        | Windows | Android | iOS | MACOS |
|------------------------|---------|---------|-----|-------|
| Chrome                 | ✓       | ✓       | -   | -     |
| Firefox                | ✓       | ✓       | -   | -     |
| Safari                 | ✓       | ✓       | -   | -     |
| Internet Explorer/Edge | ✓       | ✓       | -   | -     |

The operating systems of Apple (iOS, MacOS) do not permit the reception and display of native notifications through web apps without the download and installation of native applications on the user devices. Such applications already exist and could be used. However, they are paid apps so the user will have to pay for their installation and usage to facilitate native notifications. This would deter pilot participants from using the WiseHOME app. As an alternative, users of Apple products can be informed via SMS or e-mail instead of native notifications, since both SMS apps and e-mail clients already embed a powerful native notification mechanism. This solution can partially circumvent the problem, even if it is not the optimal one.

## 6 WiseHOME app testing

### 6.1 TESTING METHODOLOGY

Lab-testing of the WiseHOME app includes two types of testing:

- Software unit testing based on a specific testing approach, which is outlined in Deliverable 7.2 of the WiseGRID project;

The following sub-section outlines the test cases that have been defined and used to test the tool functionality.

- Alpha and beta testing by users, who provide feedback for bug tracking and optimizations to improve the user experience of the app.

The WiseHOME app has been extensively tested both at the lab premises of Hypertech by several employees as well as by external individuals – most notably pilot partners of the WiseGRID project. The app has also been presented in two workshops where perspective pilot participants attended, so some feedback has originated from the actual target user group of the application.

### 6.2 TEST CASES

#### 6.2.1 Registration of new user in WiseHOME

|                                  |   |              |     |
|----------------------------------|---|--------------|-----|
| <b>Name</b>                      | WHa0001. User registration  |              |     |
| <b>Module under test</b>         | WiseHOME app  | <b>Resp.</b> | HYP |
| <b>Module requirement</b>        | HL-UC 7 PUC 3 Clients engagement for active market participation  |              |     |
| <b>Test environment</b>          | WiseHOME framework (web/application server) up & running  |              |     |
| <b>Features to be tested</b>     | Registration of a new user in the WiseHOME application  |              |     |
| <b>Features not to be tested</b> |   |              |     |
| <b>Preparation</b>               | Launch the server-side WiseHOME back-end  |              |     |
| <b>Dependencies</b>              |   |              |     |
| <b>Steps</b>                     | <ol style="list-style-type: none"> <li>1. Go to the WiseHOME app URL</li> <li>2. Fill in the required data fields</li> <li>3. Click on the “Register” button</li> </ol> |              |     |
| <b>Pass criteria</b>             | Generation of new entry in the WiseHOME user database with the appropriate information  |              |     |
| <b>Suspension criteria</b>       |   |              |     |

|         |                 |
|---------|-----------------|
| Results | Test successful |
|---------|-----------------|

### 6.2.2 Log in of existing user

|                           |   |       |     |
|---------------------------|---|-------|-----|
| Name                      | WHa002. User log in   |       |     |
| Module under test         | WiseHOME app  | Resp. | HYP |
| Module requirement        | HL-UC 7 PUC 3 Clients engagement for active market participation  |       |     |
| Test environment          | WiseHOME framework (web/application server) up & running  |       |     |
| Features to be tested     | Log in of existing user into the WiseHOME web app   |       |     |
| Features not to be tested |   |       |     |
| Preparation               | <ol style="list-style-type: none"> <li>1. Launch the server-side WiseHOME back-end</li> <li>2. User registration</li> </ol>                         |       |     |
| Dependencies              | WHa0001. User registration  |       |     |
| Steps                     | <ol style="list-style-type: none"> <li>1. Open the WiseHOME URL</li> <li>2. Enter user credentials</li> <li>3. Press the "Log in" button</li> </ol> |       |     |
| Pass criteria             | Successful authentication of user credentials and launch of dashboard   |       |     |
| Suspension criteria       |   |       |     |
| Results                   | Test successful   |       |     |

### 6.2.3 Configuration of residential assets

|                           |   |       |     |
|---------------------------|---|-------|-----|
| Name                      | WHa003. Home asset configuration  |       |     |
| Module under test         | WiseHOME app  | Resp. | HYP |
| Module requirement        | HL-UC 7 PUC 3 Clients engagement for active market participation  |       |     |
| Test environment          | WiseHOME framework (web/application server) up & running  |       |     |
| Features to be tested     | Configuration of availability of specific assets (local generation & storage) in the user residential premises        |       |     |
| Features not to be tested |   |       |     |
| Preparation               | <ol style="list-style-type: none"> <li>1. Launch the server-side WiseHOME back-end</li> <li>2. User log in</li> </ol> |       |     |

|                            |  |
|----------------------------|--|
| <b>Dependencies</b>        | WHa0001. User registration   |
| <b>Steps</b>               | <ol style="list-style-type: none"> <li>1. Open the WiseHOME URL</li> <li>2. Enter user credentials</li> <li>3. Press the “Log in” button</li> <li>4. Open the “Configuration” tab</li> <li>5. Specify the availability of the displayed assets in the home (assetKey)</li> </ol> |
| <b>Pass criteria</b>       | The WiseHOME database should keep a proper record of the availability of these assets. The main challenge lies in managing the setting specified potentially multiple users/occupants of the same home.  |
| <b>Suspension criteria</b> |  |
| <b>Results</b>             | <i>Test successful</i>   |

#### 6.2.4 Display of KPIs on visualization dashboard

|                                  |   |              |     |
|----------------------------------|---|--------------|-----|
| <b>Name</b>                      | WHa004. Display the WiseHOME dashboard  |              |     |
| <b>Module under test</b>         | WiseHOME app  | <b>Resp.</b> | HYP |
| <b>Module requirement</b>        | HL-UC 7 PUC 3 Clients engagement for active market participation  |              |     |
| <b>Test environment</b>          | WiseHOME framework (web/application server) up & running<br>WiseCOOP/IOP up & running   |              |     |
| <b>Features to be tested</b>     | Proper operation of the visualization dashboard of the WiseHOME app by fetching and displaying relevant information from WiseCOOP   |              |     |
| <b>Features not to be tested</b> |   |              |     |
| <b>Preparation</b>               | <ol style="list-style-type: none"> <li>1. Launch the server-side WiseHOME back-end</li> <li>2. Launch the WiseCOOP &amp; IOP products</li> <li>3. User log in</li> </ol>  |              |     |
| <b>Dependencies</b>              | WHa002. User log in   |              |     |
| <b>Steps</b>                     | <ol style="list-style-type: none"> <li>1. WiseHOME app requests information to visualize from WiseCOOP</li> <li>2. WiseCOOP responds with the information</li> <li>3. WiseHOME creates the app view and instantiates visualizations/graphs</li> </ol> |              |     |
| <b>Pass criteria</b>             | Visualization of WiseHOME dashboard with information fetched from WiseCOOP  |              |     |
| <b>Suspension criteria</b>       |   |              |     |
| <b>Results</b>                   | <i>Test successful</i>  |              |     |

Note: this test case implies the integration of the WiseHOME app with the WiseCOOP product in order to be successfully executed. WiseCOOP stores all energy related information about the users/homes, while WiseHOME manages user credentials for the app. This integration has been already achieved and information flow between the two tools – over the WG IOP – has been established.

### 6.2.5 Display of messages in the WiseHOME app

|                                  |  |              |     |
|----------------------------------|--|--------------|-----|
| <b>Name</b>                      | WHa005. Display messages   |              |     |
| <b>Module under test</b>         | WiseHOME app   | <b>Resp.</b> | HYP |
| <b>Module requirement</b>        | HL-UC 7 PUC 3 Clients engagement for active market participation   |              |     |
| <b>Test environment</b>          | WiseHOME framework (web/application server) up & running<br>WiseCOOP/IOP up & running  |              |     |
| <b>Features to be tested</b>     | Reception and proper display of message/notification in the notification centre of the WiseHOME application  |              |     |
| <b>Features not to be tested</b> |  |              |     |
| <b>Preparation</b>               | <ol style="list-style-type: none"> <li>1. Launch the server-side WiseHOME back-end</li> <li>2. Launch the WiseCOOP &amp; IOP products</li> <li>3. User log in</li> <li>4. Retailers/cooperative (WiseCOOP user) creates and sends a notification via WiseCOOP</li> </ol> |              |     |
| <b>Dependencies</b>              | WHa002. User log in  |              |     |
| <b>Steps</b>                     | <ol style="list-style-type: none"> <li>1. WiseCOOP sends message to WG IOP</li> <li>2. WiseHOME listens to IOP queues and captures message</li> <li>3. WiseHOME displays the message in its notifications centre</li> </ol>  |              |     |
| <b>Pass criteria</b>             | Message properly displayed in the notifications centre of the appropriate user   |              |     |
| <b>Suspension criteria</b>       |  |              |     |
| <b>Results</b>                   | <i>Test successful</i>   |              |     |

### 6.2.6 Subscription to notifications

|                          |  |              |     |
|--------------------------|--|--------------|-----|
| <b>Name</b>              | WHa006: Subscription to native notifications                     |              |     |
| <b>Module under test</b> | WiseHOME app   | <b>Resp.</b> | HYP |
| <b>Module</b>            | HL-UC 7 PUC 3 Clients engagement for active market participation |              |     |



|                                  |  |
|----------------------------------|--|
| <b>requirement</b>               |  |
| <b>Test environment</b>          | WiseHOME framework (web/application server) up & running<br>WiseCOOP/IOP up & running  |
| <b>Features to be tested</b>     | Successful subscription to native notifications for the specific device  |
| <b>Features not to be tested</b> |  |
| <b>Preparation</b>               | <ol style="list-style-type: none"> <li>1. Launch the server-side WiseHOME back-end</li> <li>2. Launch the WiseCOOP &amp; IOP products</li> </ol>   |
| <b>Dependencies</b>              | WHa002. User log in  |
| <b>Steps</b>                     | <ol style="list-style-type: none"> <li>1. User registration to WiseHOME app</li> <li>2. User log in</li> <li>3. Appearance of pop-up window asking for user's consent to receive native notifications</li> <li>4. User acceptance</li> </ol> |
| <b>Pass criteria</b>             | Successful subscription to the native notification delivery mechanism (e.g. service worker) which can be validated either via the configuration parameters of the browser or via the successful delivery of a native notification.           |
| <b>Suspension criteria</b>       |  |
| <b>Results</b>                   | <i>Test successful</i>   |

### 6.2.7 Reception and display of notification

|                                  |   |              |     |
|----------------------------------|---|--------------|-----|
| <b>Name</b>                      | WHa007. Reception and display of native notification  |              |     |
| <b>Module under test</b>         | WiseHOME app  | <b>Resp.</b> | HYP |
| <b>Module requirement</b>        | HL-UC 7 PUC 3 Clients engagement for active market participation  |              |     |
| <b>Test environment</b>          | WiseHOME framework (web/application server) up & running<br>WiseCOOP/IOP up & running   |              |     |
| <b>Features to be tested</b>     | Reception of a notification from the WiseCOOP tool and display as a native notification in the user's device. This feature must be tested for several operating systems and browsers. |              |     |
| <b>Features not to be tested</b> |   |              |     |
| <b>Preparation</b>               | <ol style="list-style-type: none"> <li>1. Launch the server-side WiseHOME back-end</li> <li>2. Launch the WiseCOOP &amp; IOP products</li> </ol>                                      |              |     |
| <b>Dependencies</b>              |   |              |     |
| <b>Steps</b>                     | <ol style="list-style-type: none"> <li>1. WiseCOOP sends message to WG IOP</li> <li>2. WiseHOME listens to IOP queues and captures message</li> </ol>                                 |              |     |

|                            |   |
|----------------------------|---|
|                            | <ul style="list-style-type: none"> <li>3. Message is displayed as a native notification of the user device</li> <li>4. Steps must be iterated for several operating systems and browsers</li> </ul>   |
| <b>Pass criteria</b>       | Display of native notification  |
| <b>Suspension criteria</b> |   |
| <b>Results</b>             | Native notifications are fully operational for popular browsers (e.g. Firefox, Chrome, Edge, etc.) running on Windows or Android operating system. Devices running MacOS or iOS will not display native notifications. Alternative solutions are to send e-mails instead of displaying notifications. |

## 7 Conclusions

The present report documents the outcome of the design and implementation process of the WiseHOME web app, including the results of the internal lab testing performed in parallel with software development. More specifically, it documents the:

- WiseHOME app architecture including how the app fits in the overall context of the WiseGRID ecosystem
- Detailed specifications for the information exchange between the WiseHOME app and the WiseCOOP product
- User manual that guides the user through the initial phases of creating an account, logging in the app and using the app
- Test results that highlight the outcomes of the testing of the main WiseHOME functionalities within the premises of the tool developer.

The WiseHOME app is meant to serve as an engagement tool between the energy retailer/aggregator and the residential prosumer/consumer. Its main purpose is: i) to raise the awareness of the energy user regarding consumption patterns as well as their environmental and financial impact; and ii) to provide an intuitive and non-intrusive communication channel through which the retailer/aggregator can send important information about the energy system (e.g. peak retail prices, grid congestion, emission peaks) to the user so that the latter is informed and stimulated in a timely manner in order to take action. This constitutes a step toward making citizens more active energy consumers.

## 8 Acronyms

| Acronyms List |                                   |
|---------------|-----------------------------------|
| A/C           | Air Conditioning                  |
| ADR           | Automated Demand Response         |
| DB            | Database                          |
| DR            | Demand Response                   |
| ESCO          | Energy Services Company           |
| EV            | Electric Vehicle                  |
| EVSE          | Electric Vehicle Supply Equipment |
| HTML          | Hyper Text Markup Language        |
| IOP           | Inter-Operable Platform           |
| IR            | Infrared                          |
| KPI           | Key Performance Indicator         |
| MVC           | Model View Control                |
| PV            | Photovoltaic                      |
| REST          | Representational State Transfer   |
| SLA           | Service Level Agreement           |
| SMX           | Smart Meter Extension             |
| TLS           | Transport Layer Security          |
| UC            | Use Case                          |
| URL           | Universal Resource Locator        |
| WP            | Work-Package                      |