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Self Assessment Towards Optimization of Building Energy

Deliverable 5.2

WEB-based Interactive Applications Design

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Table of Contents

List of Figures

List of Tables

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V1.1	Manuel J. Fonseca (FC.ID)	Initial version	29/11/2021
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V1.4	Nuno Gouveia (Sonae /Worten)	Minor comments and adjust of some typos	16/12/2021
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V2.0	Manuel J. Fonseca and Bernardo Cabrita (FC.ID)	Consolidation of reviews, reorganization of the interface design section, and new conclusions section	11/01/2022
2.0	FC.ID	Final check, formatting, and minor corrections before submission	19/01/2022

DISCLAIMER

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EXECUTIVE SUMMARY / ABSTRACT / SCOPE

The SATO project aims to create an interactive application for the different users of the SATO platform so that they can interact with their homes and service buildings, control existing devices, as well as specify their preferences in terms of comfort, and consult the energy consumption of facilities, rooms, and appliances.

This deliverable is a direct output of Task T5.2 (Definition of actors operational interaction with SATO platform and services through friendly user-centered design). This task consisted of defining the interactions of the various actors with the SATO platform and services and designing the interface for them.

Deliverable D5.2 starts by identifying the main functionalities requested by the different actors, based on the results of the survey performed in WP1, and whose results were described in deliverable D1.1 (Role of Actors and Design of Stakeholder Framework). It also includes a brief description of some household apps for residential buildings and BEMS (Building Energy Management Systems) for facility buildings, which served as inspiration for the design of our solution.

In the interactive application design part, we started by presenting a set of personas representing virtual users of our solution and some usage scenarios to illustrate how these personas could use the different functionalities of the SATO interactive application. We also present a set of mockups of the various screens that will make up the user interface of the SATO interactive application, and the connections between them to illustrate the steps that users must take to complete the tasks described in the usage scenarios.

The design process of the interactive application followed a user-centered methodology. We used the requirements and the use cases identified in WP1 to produce the usage scenarios and the screen mockups. The resulting design is technology agnostic and will serve as the basis for implementing the Web-based interactive application to be developed in Task T5.4 (Development of easy-to-use User Interfaces for SA&O services).

1. Introduction

The SATO project provides a set of services and information about consumption and assessment measures that will only be useful if they reach the different actors of the system in a simple and effective way. To achieve this, Task T5.2 (Definition of actors operational interaction with SATO platform and services through friendly user-centered design) aimed to design the interactive assessment applications for the end-users, based on the requirements and use cases identified in T1.1 (Analysis of actors, roles, and interfaces related to A&O services) and T1.4 (Definition of Use Cases and operational Test Experiments), respectively. The interactive applications were designed to work in Web and mobile environments so that they can work on different devices (e.g. tablets, smartphones, desktop computers, etc.) and different platforms (e.g. Windows, MacOS, Android, iOS, etc.).

This deliverable is a direct output of Task T5.2, and its main objective is to present the interaction design for the interactive applications, to be used by the different actors of the SATO platform, according to the requirements and use cases identified in WP1. It will guide the implementation of the interactive applications to be developed in Task T5.4 (Development of easy-to-use User Interfaces for SA&O services).

In this deliverable we followed a user-centered approach and iterative design, typically used in user experience and interaction design to assure that the resulting design as a good usability and user experience for the potential users. We started by identifying the functional requirements for each actor of the SATO platform, based on the requirements identified in deliverable D1.1 and on the use cases defined in deliverable D1.5. Next, we created a set of personas (virtual users of the interactive applications) covering the different types of users to be supported by the applications. Using these personas, we wrote a set of user scenarios to illustrate how our interactive applications would be used by their actors to achieve their goals. These scenarios allowed us to explore how the different functionalities would be performed by users to achieve their goals and to check if they are aligned with the users' needs. Finally, we designed a set of mockup screens and storyboards for the interactive applications to show how we envision the applications, and how users would interact with them to perform the several scenarios and achieve their goals.

The remaining of this document is divided into other four sections. Section 2 presents the different actors of the SATO interactive applications and their main needs. Section 3 briefly describes some existing household applications and building energy management systems. Section 4 describes the interactive application design, by presenting a set of personas for the SATO interactive applications, user scenarios for these personas, and a set of storyboards for some user scenarios. We conclude the deliverable by presenting some conclusions and final remarks.

2. Actors Main Needs

Based on Deliverables D1.1 (Role of Actors and Design of Stakeholder Framework) and D1.5 (Description of the Use Cases and Test Experiments), we have drawn important information about the needs of the human actors. The actors, divided in three categories - Occupant, Facility/Building manager, and Grid operator - have different preferences and interests in common when using the SATO platform, as we can see in Table 1.

Occupants have more direct control over their energy systems in a residential or service building. Thermal and visual comfort are the main drivers for users' actions. Therefore, extreme temperatures during the summer and winter seasons and improper lighting levels were mentioned as the most significant sources of discomfort. Consequently, they want to aggregate heating, lighting, air conditioning, ventilation, and automated blinds and/or shades. Respectively to the interface, **occupants** want it to feature ease-of-use, thermal comfort monitoring, automated control over energy systems, and would like to aggregate heating, cooling, and lighting.

Table 1: List of needs for each type of actor of the SATO platform.

	Actor		
Energy systems	occupant (residential and service building)	building/facility managers	Grid operators
Heating	✓	✓	✓
Ventilation	✓	✓	✓
Air Conditioning/Cooling	✓	✓	✓
Lighting Systems	✓		
Automated blinds and/or shades	✓		
Ease-of-use	✓	✓	
Thermal comfort monitoring	✓		
Automated control over energy systems	✓	✓	
Historical database energy consumption	✓		
Energy consumption at real time		✓	
Aggregate heating, cooling, and lighting	✓		
Sanitary hot water		✓	
Amount of power available		✓	
Load Shifting			✓
Flexibility forecast			✓
Flexibility dispatch			✓
EV charging station			✓
Air handling units			✓
PV and electric boilers power information			✓

Facility/Building managers supervise the building's operation mode; the three main discomfort factors are cold during winter, heat during summer, and noise. Also, bad air quality, improper lighting, and air draft highly contribute to thermal discomfort. They want to aggregate heating, ventilation, and air conditioning. As for the user interface, they want it to feature ease-of-use, automated control over the energy systems, real-time energy consumption data, and useful comparisons to support value-added decision makings.

Lastly, for **grid operators**, load shifting is the most crucial functionality, along with flexibility forecast and flexibility dispatch. The most wanted energy systems for flexibility are heating, lighting, air conditioning, EV charging station, air handling units, PV, and electric boilers. These energy services tend to be the largest sources of energy consumption in buildings and could also be the energy systems with a central role for the flexibility services mentioned above. Since most of the functionalities desired by grid operators are outside of the SATO platform, we will not consider their needs in the design of the SATO interactive applications for the moment. Instead, we consider building owners.

3. Household Apps and Building Energy Management Systems

In this section we provide a brief description of some of the existing mobile applications and Web applications used to manage and control smart homes as well as three of the most used building energy management systems.

3.1. Household Applications

3.1.1. Samsung SmartThings

SmartThings [1] is a mobile phone app made by Samsung that can help users control their smart homes. It offers shortcuts in the main screen for Favourites, Devices, Life, Automations, and menu. Users can also select the Home they want to control (if they have more than one), add a device, a scene (which is a set of operations performed in sequence), an automation, or defining the settings. The Favourite section provides a list of status information (e.g. opened fridge, opened windows, low battery, weather, etc.), scenes, home devices and services. It supports home appliances from different brands, is compatible with assistants like Amazon Alexa or Google Assistant, and has a clean and easy to use user interface.

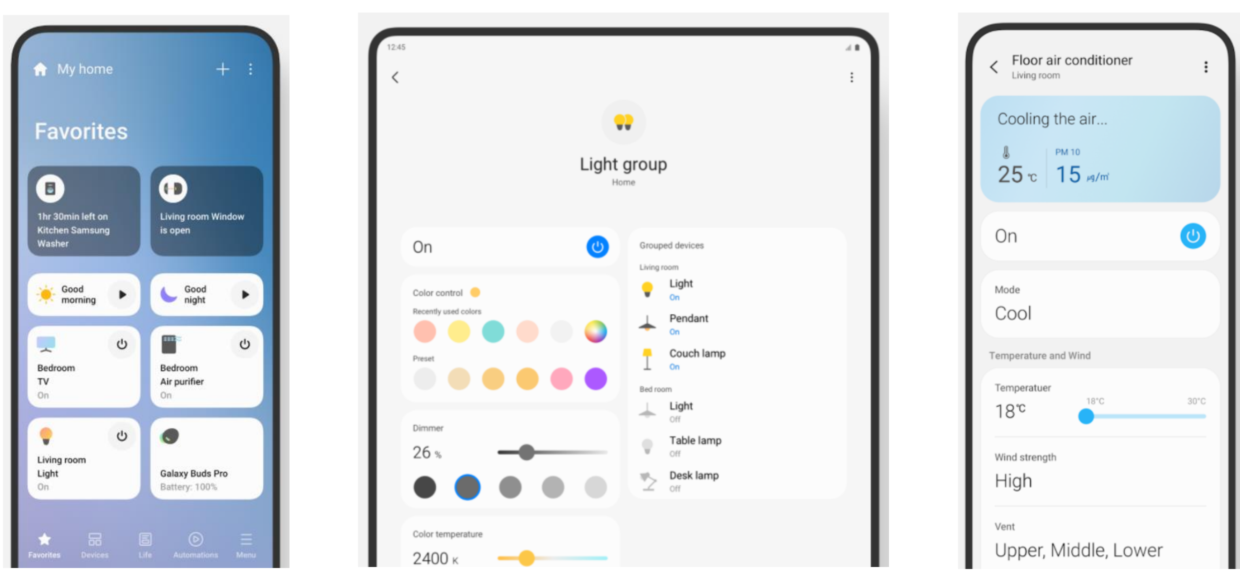

Figure 1: Screenshots of the Samsung SmartThings App.

3.1.2. Google Home

Google Home [2] is a virtual assistant that can integrate a wide variety of smart home devices with the mobile app, allowing users to access their smart devices using voice commands only. It supports several languages that customers can use to control their devices. Users can control lights, cameras, thermostats, create routines, change settings, among other functionalities. It can organize devices by rooms or display all devices of a particular type that exist in the home. It supports devices from multiple brands and can only interact with Google Assistant.

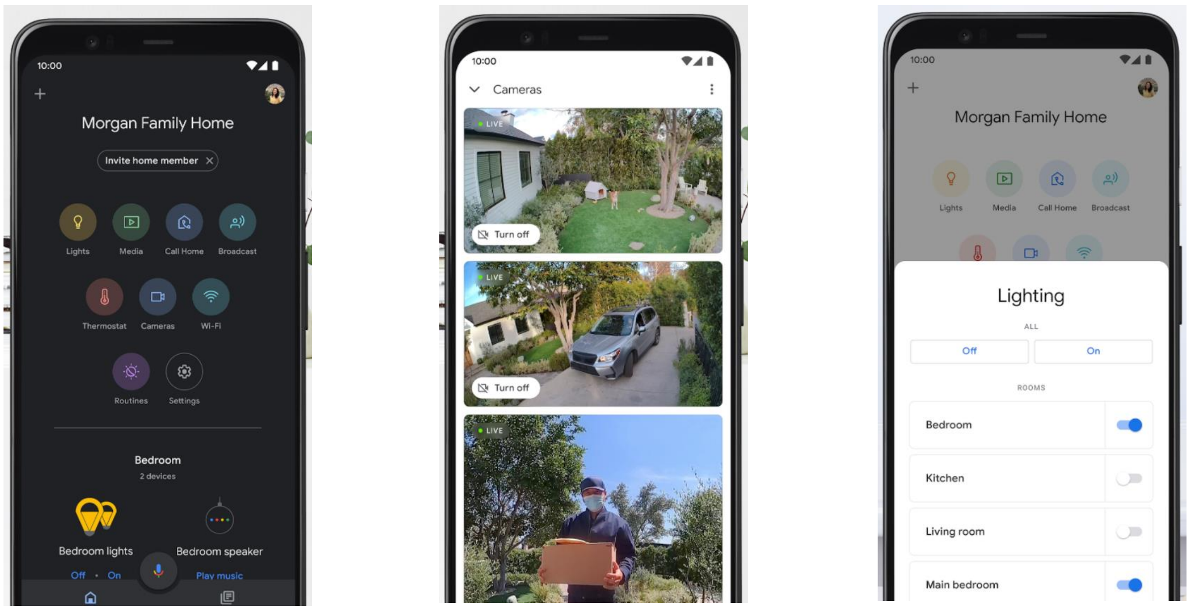

Figure 2: Screenshots of the Google Home App.

3.1.3. Apple Home

The Apple Home App [3] allows us to control individual accessories and scenes with multiple devices, create automations, and access advanced settings. Users can access the Home, rooms, automations, and cameras. They can access devices by room or by type, define sequences of actions (scenes) that can be performed at specific times of the day, or identify the favourite devices. User can interact using voice commands through Siri and use devices from different brands.

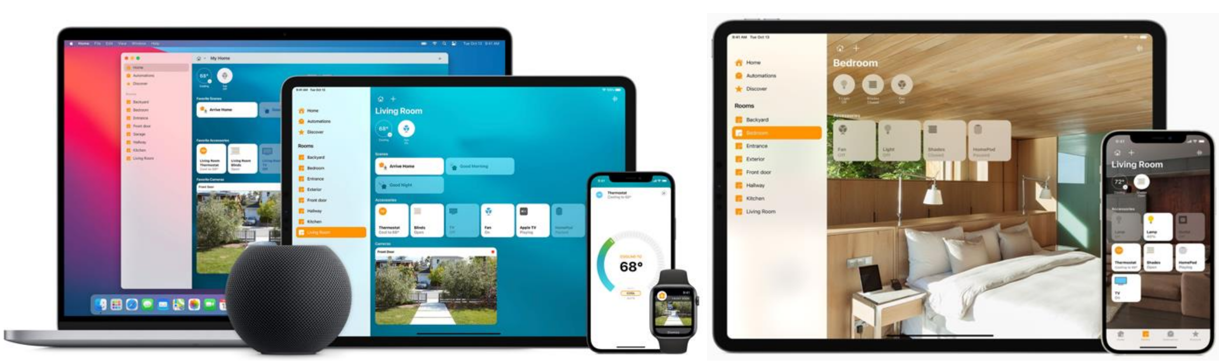

Figure 3: Screenshots of Apple Home App.

3.1.4. Home Assistant

Home Assistant [4] is free and open-source home automation platform that allows products from different manufacturers and using different protocols to integrate seamlessly. It was designed to be the central control system for smart home devices with a focus on local control and privacy. It is powered by a worldwide community of tinkerers and DIY enthusiasts. The platform can run on a Raspberry Pi or a local server, and it allows users to monitor devices and energy usage, helping them transitioning to sustainable energy and save money. It can be accessed via a web-based or mobile user interfaces, or using voice commands through virtual assistants such as Google Assistant or Amazon Alexa.

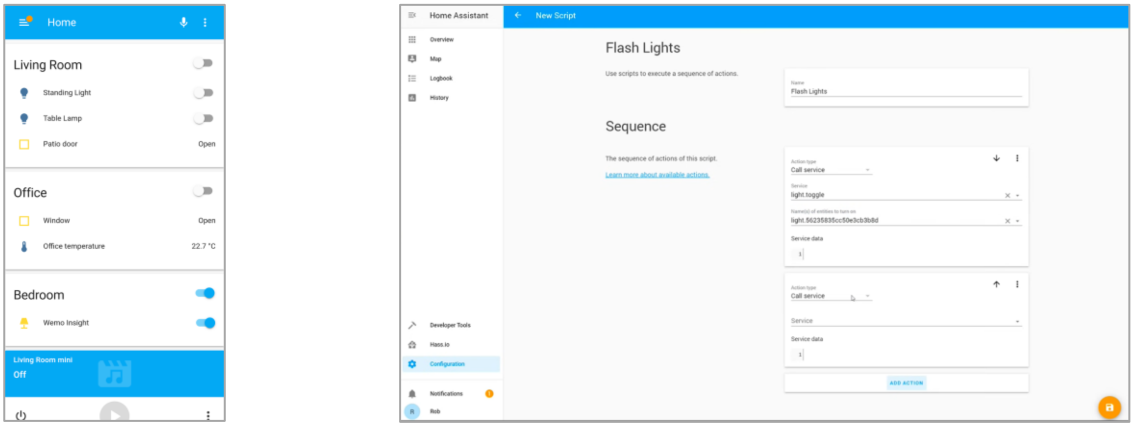

Figure 4: Screenshots of the Home Assistant platform.

3.1.5. Homey

Homey [5] is a smart home center Athom B.V, and it works as a central point of configuration, control, automation and monitoring of components in a smart home. It allows the creation of control flows composed by several appliances and equipments and offers an application interface with an open API that allows third-party developers to add support for their products in Homey. It can integrate devices from multiple brands and is compatible with Amazon Alexa and Google Assistant.

Its application provides detailed energy monitoring, allowing users to save money on electricity bills and live in a more sustainable way. It also offers access settings, user account, addition of devices, and notifications. Users can see the devices by room, using three different display layouts.

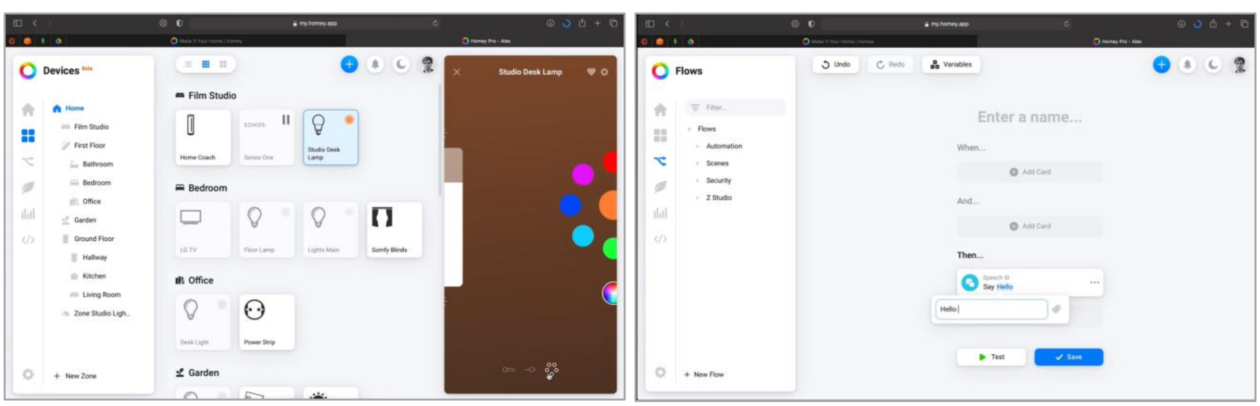

Figure 5: Screenshots of the Homey application.

3.1.6. EDP Re:dy

EDP re:dy (Remote Energy Dynamics) allows residential consumers to comprehensively manage all the energy in their home in real time, to reduce costs and optimize usage. User can set limits for how much they want to spend every month, and the service notifies them when they are approaching the budget limit. User can also remotely control devices and have access to all their electricity consumption data. The reports include daily consumption data, rate-period data, device data, and subscribed capacity analysis. Finally, it allows users who have solar production to consult all the information related to it and proposes actions for the equipment to achieve the best balance between grid consumption and solar production to reduce the amount of energy injected into the grid.

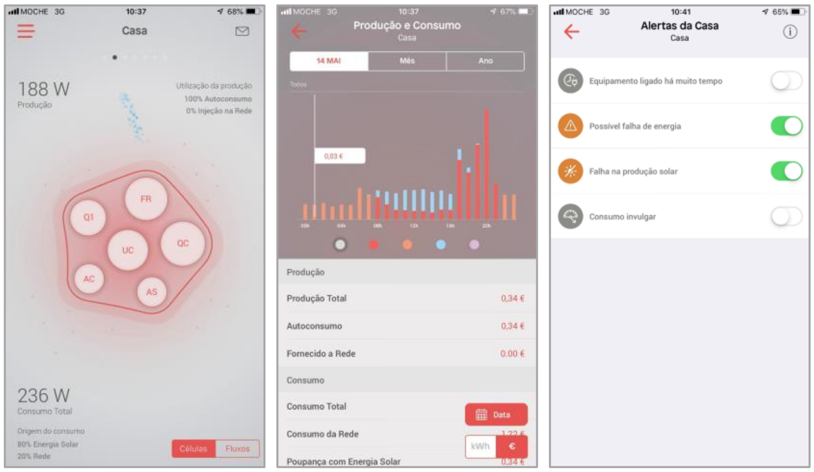

Figure 6: Screenshots of the EDP Re:dy App.

3.2. Building Energy Management Systems

3.2.1. Siemens Navigator

Siemens Navigator [7] is a cloud-based data management platform designed to help optimize building performance. It integrates seamlessly data from energy procurement, energy consumption, system performance, and sustainability. It allows monitoring the system performance from the building envelope

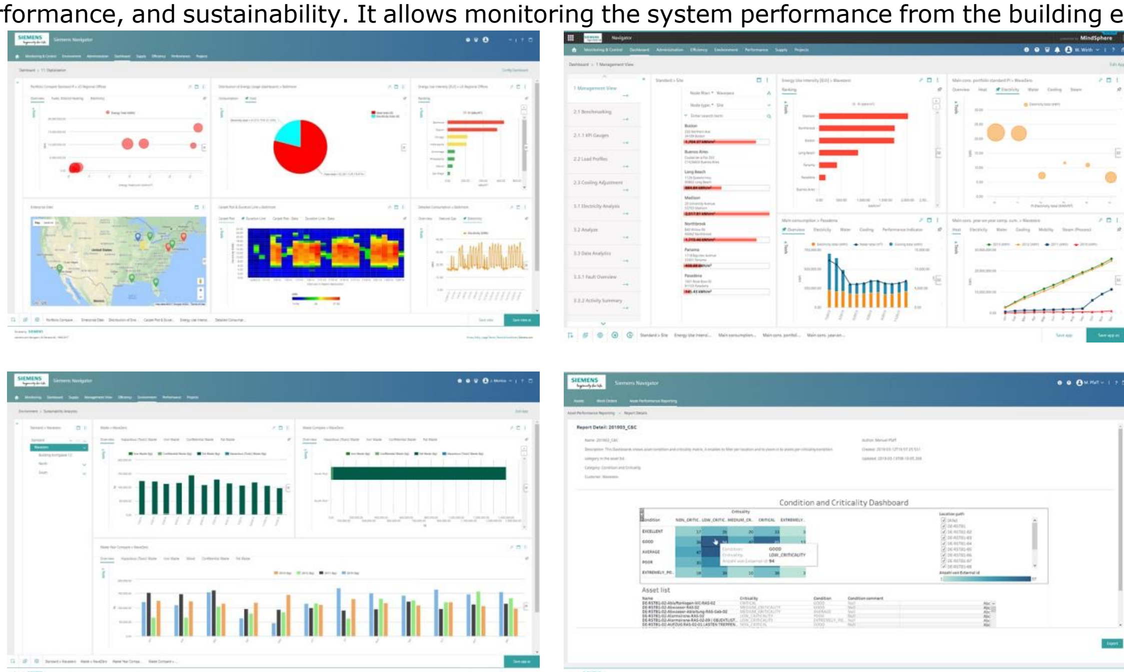

Figure 7: Screenshots of the Siemens Navigator BEMS.

to individual equipment and meters, as well as energy usage, greenhouse gas inventory, and total CO2 emissions, over time and across buildings. Users can improve energy efficiency by tracking consumption patterns and establishing benchmarks and key performance indicators (KPIs) and can customize the offered dashboards to review facility performance and monitor KPIs.

3.2.2. Schneider Electric EcoStruxure Building Advisor

Schneider Electric's EcoStruxure Building Advisor [8] is an integrated building management tool that uses input from building management systems and connected devices and applies analytics to make recommendations for improvement in energy, comfort, and maintenance, and to identifying faults to proactively address building inefficiencies. It offers a single portal with a complete view of the entire building portfolio, continuous monitoring, and a comprehensive view of building systems. The tool can generate reports periodically, indicating the priority of the nonconformance, determined by the degree of wasted money and energy, and methods to make improvements. The tool also gives real-time trending data that is invaluable to determining building comfort levels and trends and optimizing set points.

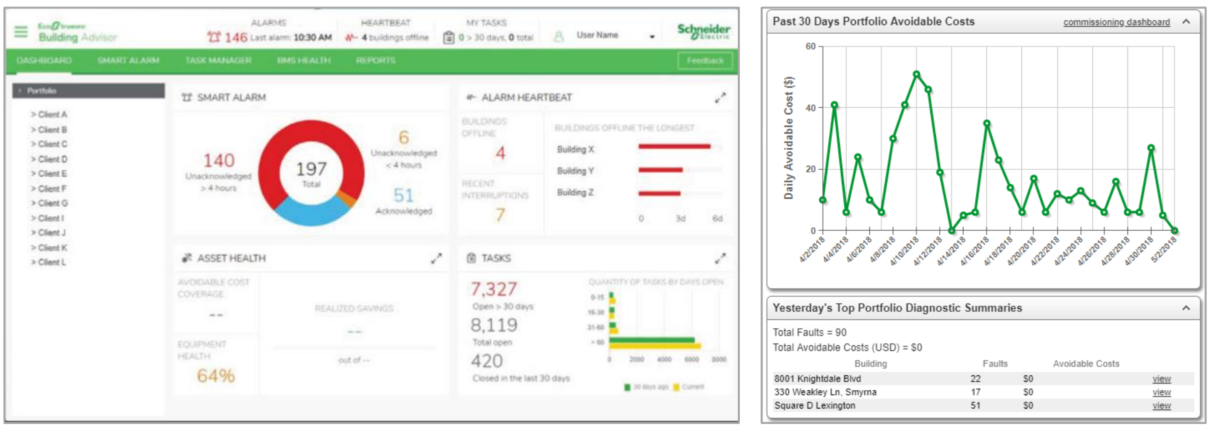

Figure 8: Screenshots of the Schneider Electric EcoStruxure Building Advisor.

3.2.3. Sauter EMS

SAUTER EMS [9] allows visualizing and exploiting all data related to energy consumption and carbon emissions in organizations. It provides information to act more effectively around energy, cost, and facility efficiency. Several visualization elements are available (tables, maps, graphs and custom elements) to support the analysis that needs to be done. It offers calculation capabilities for determining CO2 equivalencies, comparing invoices with estimated quantities, or typical consumption figures. In addition, it can automatically send reports of consulting collected or defined alerts.

Figure 9: Screenshots of Sauter EMS application.

4. Interactive Application Design

In this section we present the design of the interactive application, to support the different SATO users. To design the user interface of the application, we followed a user-centered approach, by first identifying the functional requirements for each actor of the SATO platform, already identified in deliverables D1.1 and D1.5. From these requirements we defined the set of functionalities to be provided to each actor.

Next, we created a set of personas for each actor type, which are rich descriptions of imaginary people representing typical users. They were created based on the profiles identified in the requirements gathering (D1.1) and use cases (D1.5). Creating these personas allowed us to answer the question "For whom are we developing the system?" and helped us think about how different personas will react to our application.

Based on these personas, we wrote a set of user scenarios, which are stories that show how potential users (personas) might act to achieve goals using the application. These scenarios allow us to understand the users' motivations, needs, barriers, and other aspects in the context of using the solution. User scenarios also serve to help ideate, iterate, and test the usability of our solution.

Finally, we designed storyboards for each scenario. Storyboards are sequences of screenshots showing how the users would interact with the application to complete the scenarios. These scenarios have two objectives, on the one hand they illustrate how tasks are completed and goals are achieved using the SATO user interface, and on the other hand they present the design we have reached for the interface, showing the various screens that compose it. On these screens we present the information that will be displayed, as well as the functionalities available to users.

In the next subsections we present for each of the three SATO actors (Building owners, Building Occupants, and Facility/Building Managers) a couple of personas, user scenarios, and storyboards for some of the user scenarios, to illustrate the design we created for our application.

4.1. Building Owners

4.1.1. Functionalities

For building owners, the main functionalities offered to them are the addition of new equipment to buildings and the monitoring of their consumptions.

4.1.2. Personas

P01: James - James is 58 years old and a very calm person. He is divorced and has two children. Currently, he lives with his girlfriend in a modest apartment. He loves music and traveling around the world, so he never stops at home. James owns several buildings throughout Lisbon, some of which are company business buildings. Managing all these buildings requires rules and discipline. Therefore, he imposes constraints on the building energy system operation to perform as he wants.

4.1.3. User Scenarios

User Scenario US01

Persona: P01 (James)

Goal: Addition of a new equipment and building monitoring.

James acquired and installed a new HVAC and air handling unit for an uncontrolled and unmanaged building zone of his building. He then adds the equipment to the SATO platform to record and visualize its energy consumption, to control thermal comfort in the building zone, and to assess the energy performance of the newly acquired equipment. (See Figure 10)

4.1.4. Storyboards

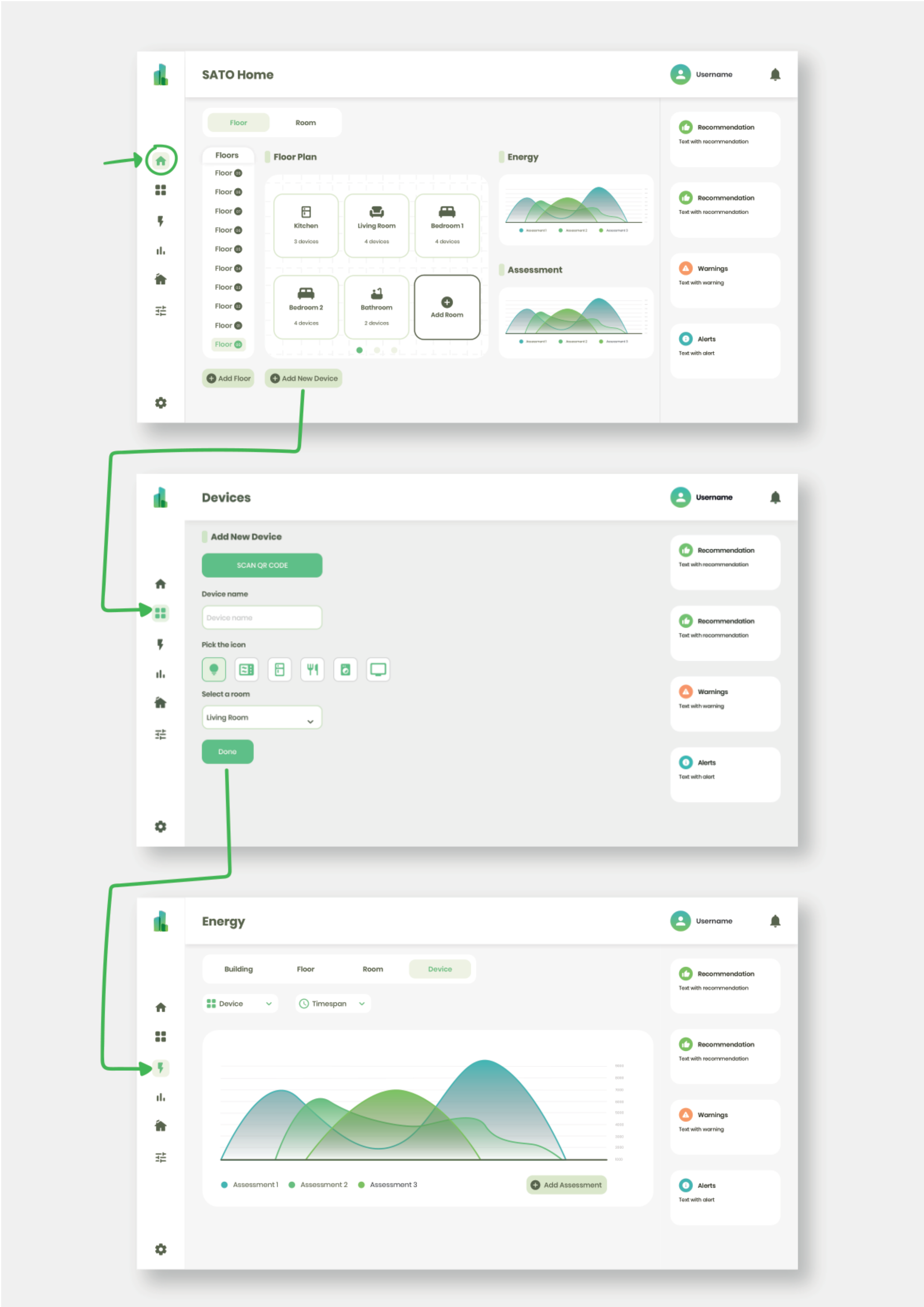

Figure 10: Storyboard for User Scenario US01.

4.2. Building Occupants

4.2.1. Functionalities

Building Occupants' offered functionalities are controlling building devices, monitoring their energy consumption and production, interacting with the notification panel, understanding CO2-emissions, and adjusting comfort based on feedback.

4.2.2. Personas

P02: Mary - Mary is 55 years old. She is a very busy woman and always with stuff on her mind. Her head revolves around three main things, her kids, home, and work. Home is the place where she clears her mind and loves to be. Her house is equipped with solar panels, and all the lighting is energy-efficient, and the appliances follow the same path. Since she has solar panels, she loves to understand how much they produce or how their energy is being used. The control and the knowledge of energy usage are essential to her to keep a low ecological footprint. She is always open to improving and learning new ways to maximize energy savings and keep in-house comfort.

P03: Robert - Robert is 35 years old, lives with his wife and kids, and is a passionate worker and tech lover. Robert works for a tech company and likes to be on top of every new technology. Since his job is well paid, he can afford to buy expensive devices that compensate long-term. Robert has 11 solar panels at home and want to understand how to get the most out of the energy produced and never spends more than he produces. For instance, if some appliances working at the same time exceed the amount of energy produced, they should never work simultaneously. Or, if some of the energy is not being used, another device should be turned on to waste no energy. For Robert, understanding this kind of management would make him feel better by knowing that he can produce clean energy and manage it the best way.

4.2.3. User Scenarios

User Scenario US02

Persona: P02 (Mary)

Goal: Real time and historical energy consumption.

Mary had just arrived home, and it was cold outside. She uses the SATO app to turn on the air conditioning, the lights, and the kettle to make tea. To understand the energy spending of the appliances, she checks on the SATO application how much energy they are consuming at that moment, and the consumption history over the last month. (See Figure 11)

User Scenario US03

Persona: P02 (Mary)

Goal: Visualize energy consumption by room and device; Visualize energy production.

Mary's morning routine consists of preparing breakfast, taking a shower, and getting prepared for the day. Typically, every week, she uses the SATO app to acknowledge the energy spent at home. She checks the consumptions per room and per device, and the energy produced by her solar panel, to determine the overall balance.

User Scenario US04

Persona: P02 (Mary)

Goal: Comfort feedback.

Mary works for John's company, and lately in the office there has been a lot of noise and the room temperature has been unpleasant, because Mary feels cold. She uses the SATO application to give feedback to the SATO platform about her discomfort in terms of noise and temperature, so that the system can adapt accordingly.

User Scenario US05

Persona: P03 (Robert)

Goal: SATO application alerts and recommendations; Visualize energy consumption and production.

On the weekends, clothes and dishes pile up all over Robert's house. He and his wife use both the dishwasher and washing machine to make their work easier. While both machines are working, the SATO app sends Robert an alert and recommends that he turn off one of them because the combined energy exceeds what the solar panels are producing. He visualizes the instantaneous energy consumption and the energy being produced, to understand why the SATO app made that recommendation. (See Figure 12)

User Scenario US06

Persona: P03 (Robert)

Goal: Alerts and notifications about unusual consumptions.

Robert has three kids, and most of the time they leave the lights on, the fridge open, the front door open, and the TV on. All of this reduces energy optimization in his home. Fortunately, the SATO app sends alerts and notifications about unusual consumption, thus preventing this type of situation and helping Robert to better manage energy. In addition, using the SATO app, he can turn off the devices without leaving the sofa.

User Scenario US07

Persona: P03 (Robert)

Goal: Alerts and notifications about decision-making related to repairing services, and new appliances.

Robert notices the laundry basket is way too full. Consequently, he puts the clothes to wash. After some minutes, he receives an alert from the SATO app suggesting him to replace the current washing machine by a new one, because lately its consumption has been increasing unusually. Along with the alert, the SATO application also suggested a list of very efficient washing machines to buy that could reduce energy consumption.

User Scenario US08

Persona: P03 (Robert)

Goal: Adding a new device.

Robert followed the suggestion of the SATO app and bought a new washing machine. He used the application to add the new appliance to his kitchen. Since the washing machine was listed on the SATO platform, the adding process was easy and straightforward. Finally, Robert configured the application so that he could track energy consumption and control the washing machine. (See Figure 13)

4.2.4. Storyboards

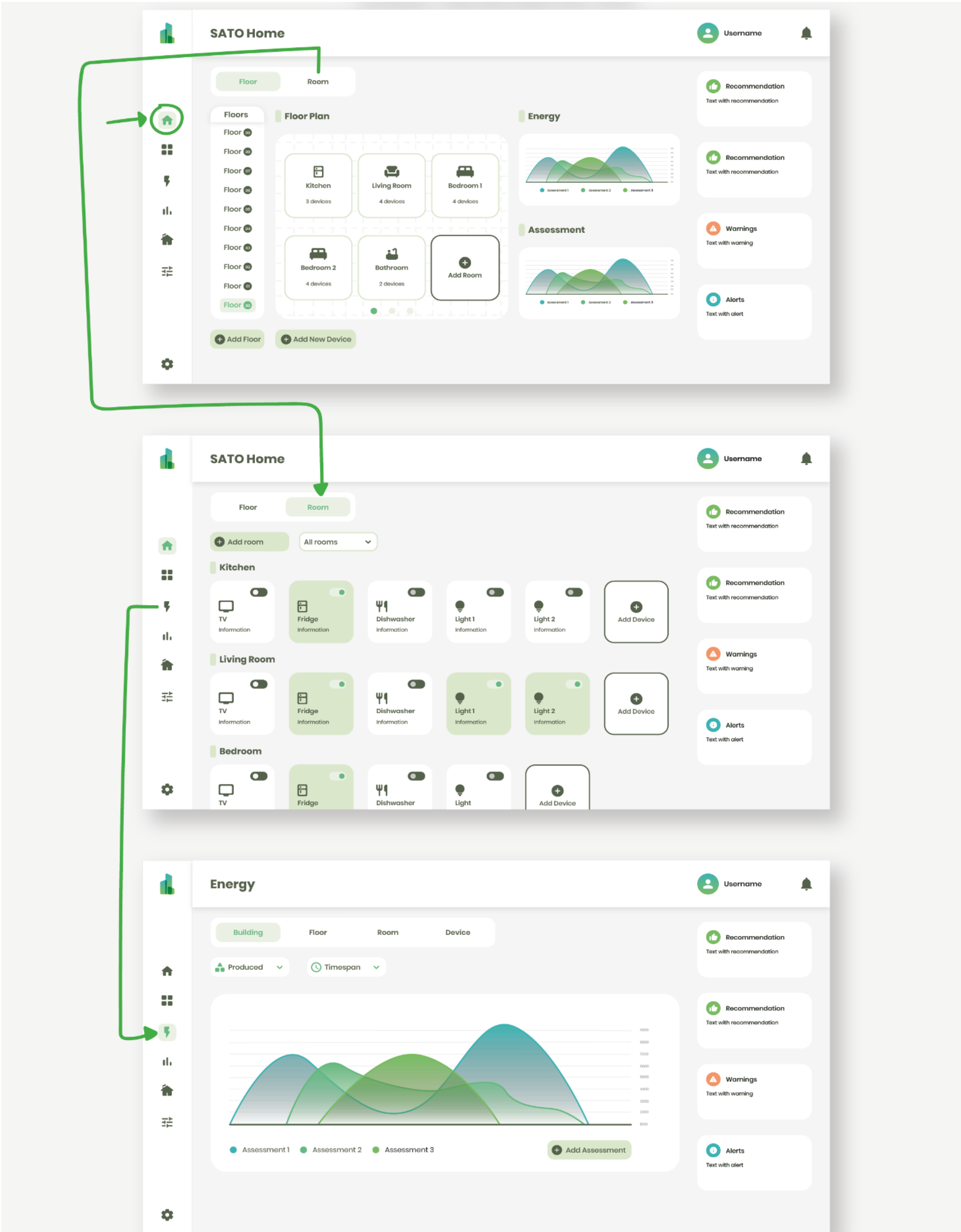

Figure 11: Storyboard for User Scenario US02.

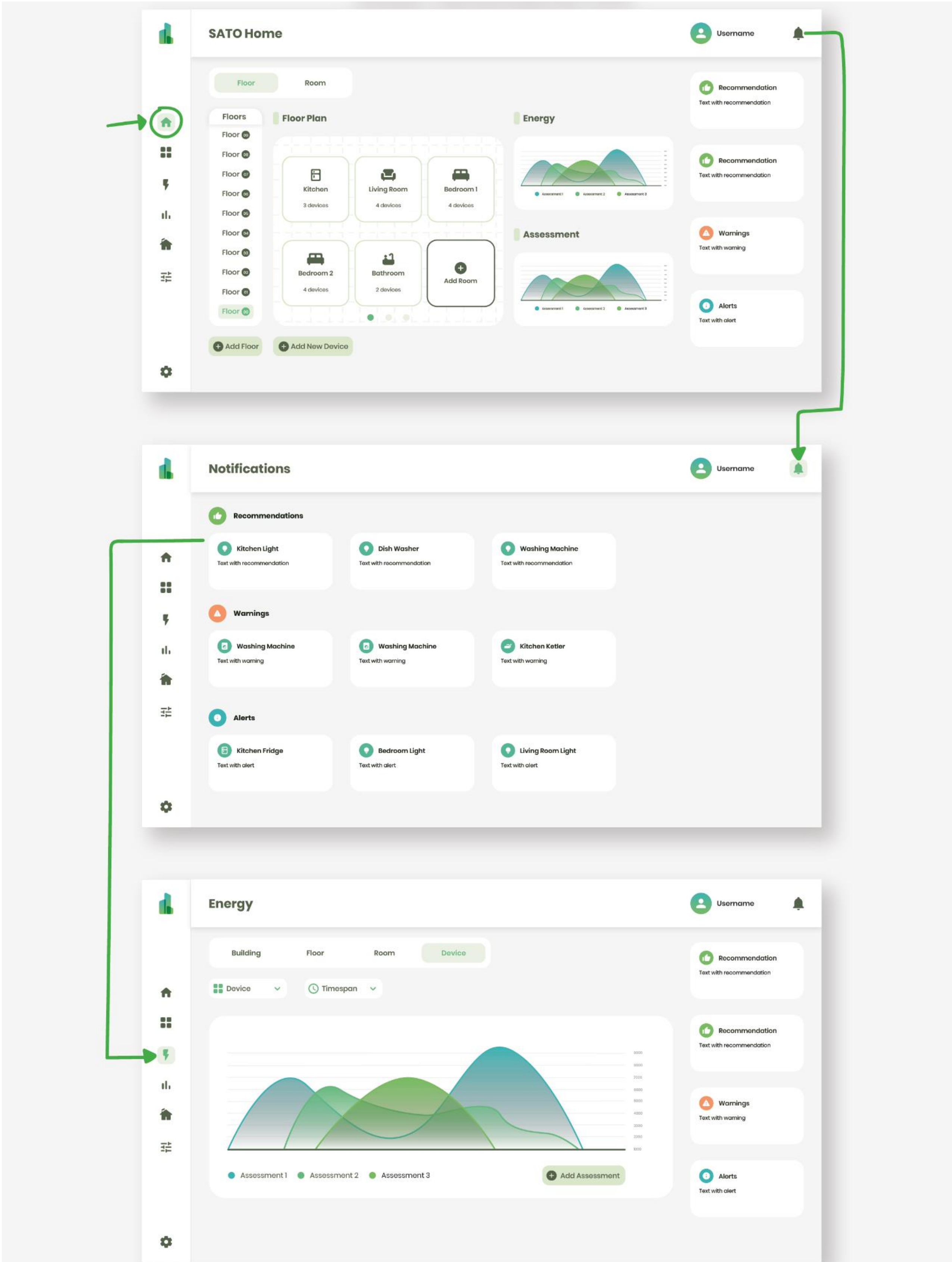

Figure 12: Storyboard for User Scenario US05.

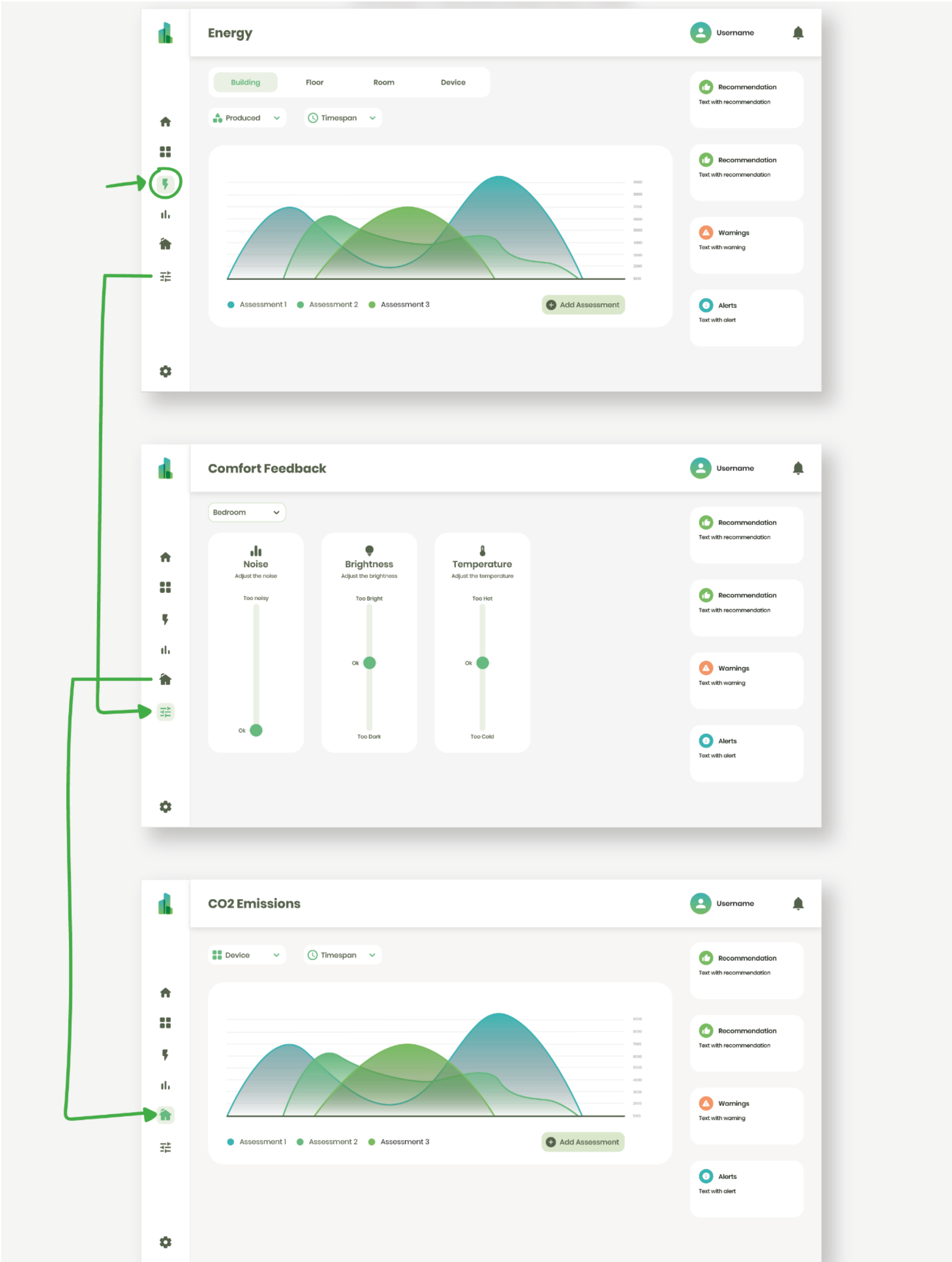

Figure 13: Storyboard for User Scenario US08.

4.3. Facility/Building Managers

4.3.1. Functionalities

The main functionalities for Facility/Building Managers are visualization of room comfort conditions, CO_2 emissions, and whole-building energy consumption.

4.3.2. Personas

P04: John - John is 40 years old and owner of a big bike company. He is a nature lover. His house is full of plants, big windows for natural light, and clean energy-producing machines. John loves to go outside and explore nature with his wife and kids, whether walking, running, or riding a bike. Having a love for nature, he is always worried about his company's energy performance, but maintaining his employees comfortable. Also, John would love to have a clean energy company, and because of it, he is always controlling how he can reduce CO_2 emissions.

P05: Michael - Michael is 26 years old and just rented a new place for his new start-up. He still lives with his parents and brother but plans to move out soon. Michael has an outgoing personality, loves to communicate, and connect with people worldwide. For him, this start-up is everything. Therefore, every penny used must be worth it. Optimizing energy consumption and maintaining employee comfort are essential.

4.3.3. User Scenarios

User Scenario US09

Persona: P04 (John)

Goal: Visualization of room comfort conditions and CO_2 emissions.

After installing the SATO app, John started following the thermal comfort feedback from his employees of the company rooms and verified that the system was adapting according to their feedback. Furthermore, he visualized the impact of the changes implied by the feedback on the CO_2 emissions of his company to assure that it still has a low ecological footprint.

User Scenario US10

Persona: P05 (Michael)

Goal: Visualization of zones and whole building energy consumption.

Michael has noticed that lately the energy consumption of his start-up has increased. As he wants to keep his start-up’s costs under control, he uses the SATO app to monitor the energy consumption of the entire building, and of each of the zones individually. Based on this information he adjusts the company's practices towards a more efficient energy use. (See Figure 14)

4.3.4. Storyboards

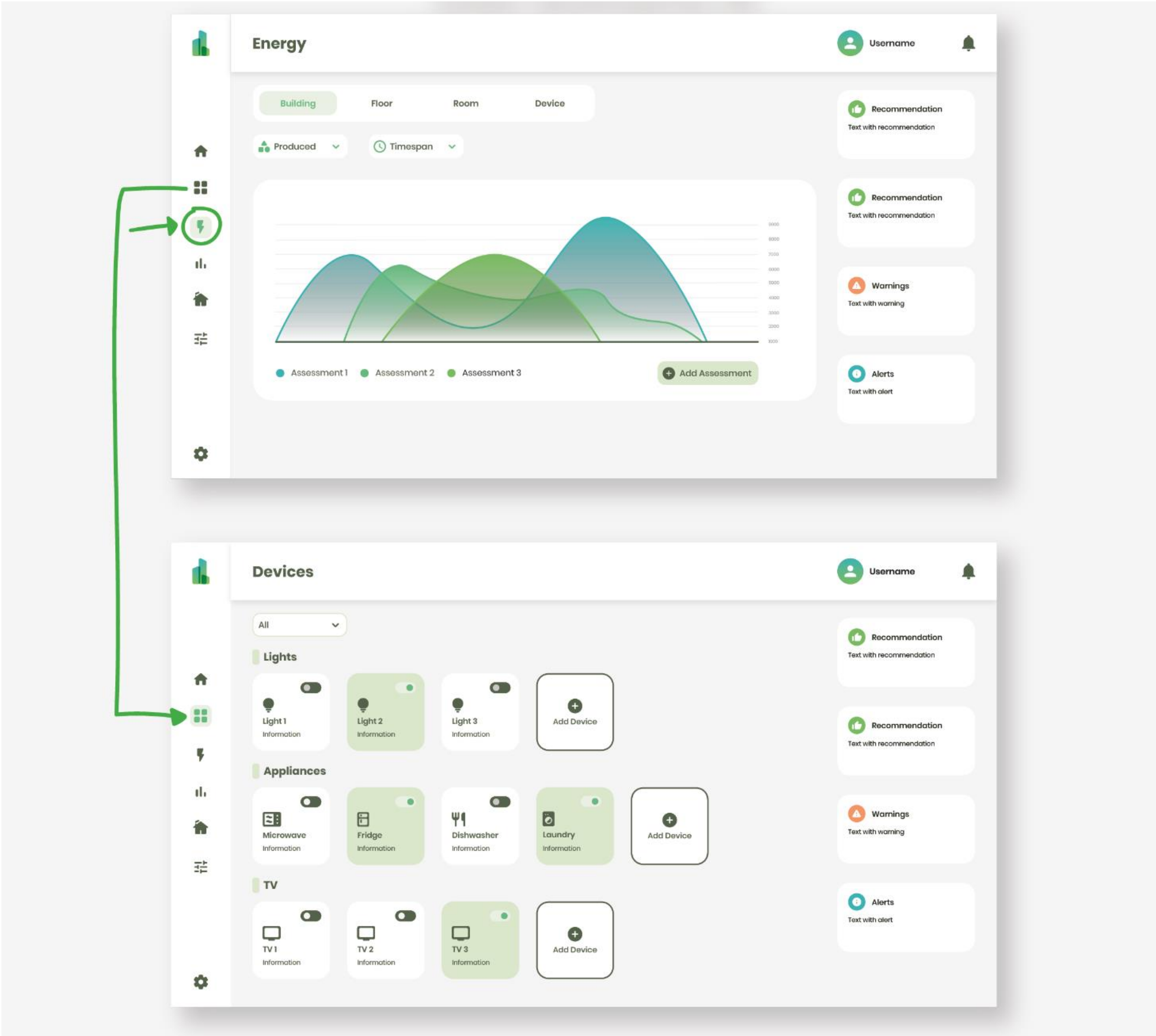

Figure 14: Storyboard for User Scenario US10.

5. Conclusions

This deliverable presented the design of the interactive applications for the different SATO actors. We started by identifying the main functional requirements desired by the different actors, according to the requirements and use cases identified in deliverables D1.1 and D1.5, respectively. Based on this, we defined a set of virtual users of the application (personas) and created user scenarios for them, to illustrate how users can achieve their goals through the SATO interactive applications. Finally, we designed mockups for the different screens of the application, showing how the different components of the user interface will be in the screen and how the users can interact with them to perform the functionalities offered to them. We also created storyboards with these screen mockups to show the sequence of steps needed to perform specific user scenarios.

These screens of the application will be used latter to conduct evaluation sessions with users of the SATO platform, to identify potential usability problems that may exist, and to receive comments and suggestions for improvement from users.

Although this design has been made based on the initial requirements from D1.1 and the use cases from D1.5, new requirements may emerge during evaluations with users. As we are using iterative and user-centered development, these new requirements will be easily integrated into the interactive SATO application.

The resulting user interface design will guide the development of the interactive applications to be implemented in Task T5.4 (Development of easy to use User Interfaces for SA&O services).

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