Intelligent Assistants for Flexibility Management
(Grant Agreement No 957670)

D3.4 Initial Natural User Interfaces

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List of abbreviations

Abbreviation	Term
A&M (Interface)	Aggregator and Market (Interface)
AFM	Automated Flexibility Management
AI	Artificial Intelligence
API	Application Programming Interface
BRP	Balance Responsible Party
CSS	Cascading Style Sheets
DR	Demand Response
DTR	Digital Twin Repository
EMS	Energy Management System
ENTSO-E	European Network of Transmission System Operators for Electricity
HLUC	High-Level Use Case
HTML	Hypertext Markup Language
IEC	International Electro-Technical Commission
IEEE	Institute of Electrical and Electronics Engineers
iFA	iFLEX Assistant
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
MVC	Model-View-Controller
oBIX	Open Building Information Exchange
PED	Positive Energy District
PUC	Primary Use Case
RAI	Resource Abstraction Interface
REMAP	Real-time Energy Metering & Actuation Platform
REST	Representational State Transfer
RWD	Responsive Web Design
SO	System Operator
SUC	Secondary Use Case
SVG	Scalable Vector Graphics
UC	Use Case
UI	User Interface
UML	Unified Modelling Language
XML	Extensible Markup Language

Executive summary

This report has two main objectives, to serve as a guide for the development process of the User Interface components of the iFLEX Assistant (iFA) and to facilitate quick integration between different existing solutions and component prototypes. Towards the 1st goal, a detailed list of requirements concerning the User Interface is documented with the focus lying primarily on Phase 1. With regards to the latter goal, existing solutions and up-to-date progress on the User Interface components is documented as a base.

In the context of the iFLEX project, a solution is developed - the iFA - aiming at facilitating consumers and/or prosumers at the level of individual premises or at the level of a community (building level) to improve the efficiency and sustainability performance of their premises, whilst enabling participation in energy markets by offering demand side flexibility services to relevant market actors. From the perspective of these actors, various flexibility procurers (e.g. System Operators - SOs, Balance Responsible Parties - BRPs), can leverage flexibility from small-scale end users of the power system.

The iFLEX project is based on a user-centred design approach aiming to simplify the participation of small-scale consumers and prosumers in flexibility services while ensuring a good user experience. The concept of co-creation with end users is deemed to be critical by the project, so that the iFLEX solution is tailored to the actual needs and wills of the users. Following the iterative design approach of the project, the design work conducted in this activity is initially validated and refined within the project consortium boundaries through workshops and questionnaires for assessing user experience. In the next phase, design validation and co-creation activities will be extrovert and involve pilot sites' users.

This deliverable falls within T3.3 of the project, which concerns the development of user interfaces that facilitate the interaction of end users with their iFAs. According to the project's targets regarding user interfaces, the solution should be able to operate respecting users' preferences, provide users with insights into their energy and flexibility performance, and be customisable with respect to the level of autonomy based on the desires of its users.

The design work was based on the requirements documented in D2.1 and the initial common architecture of the iFLEX Framework described in D2.3. Existing solutions related to user interfaces were also considered in the design of the solution, hence they are also described in this document. These solutions will be extended or partly integrated into the iFA instances for the various pilot sites of the project. Finally, the design was highly impacted by the requirement engineering work conducted in parallel with the activities documented in this report. A list of more granular requirements concerning the User Interface component is documented in the Appendix, presenting a prioritisation on a pilot basis.

The methodology adopted to document the design is based on the Viewpoints and Perspectives framework and ISO/IEC/IEEE 42010:2011 "Systems and software engineering—Architecture description". Design specifications will guide the development during the first phase of the project. More specifically, three views of the system architecture are described:

- Context view, presenting the interactions of the User Interface component with its environment at a high level;
- Functional view, focusing on the component's responsibilities and primary interactions with the iFA end users and other components of the Assistant; and
- Information view, detailing a static view of information objects relevant to the UI component, with the aim to serve as common ground for data flows exchanged between components developed by various project partners.

The report also documents part of the work conducted for the User Interface design, presenting some initial mock-ups that will be used for validation of the specification during Phase 1, considering the iterative design approach followed in the project.

This document provided a set of specifications concerning the User Interface component of the iFA aiming to assist development, integration and piloting activities during the initial phases of the project. After this 1st iteration, functionalities relevant to the User Interfaces will be refined and/or new will be added, whilst relevant work will be documented in subsequent iterations, namely deliverables D3.5 and D3.6.

1 Introduction

The iFLEX project is a response to the call LC-SC3-EC-3-2020, entitled "Intelligent Assistants for Flexibility Management", of the Horizon 2020 program. Key objectives of the iFLEX project are:

- To develop AI-enabled modelling, optimisation and user interface methods for consumer flexibility management and load forecasting;
- To design and develop modular, secure and interoperable interfaces and data management services for consumer flexibility management;
- To design and implement novel user engagement, incentives, and market mechanisms for consumer-centric demand response, whilst respecting consumer rights.

The various components developed by the solution providers who are involved in the project will be integrated into a holistic software framework for flexibility and energy management, namely the iFLEX Framework. Based on this framework, application-specific iFLEX Assistant prototypes, customised for services provided by the industrial partners of the project, will be deployed and tested through pilots in three different countries, namely Finland, Greece and Slovenia.

This document falls within T3.3 of the project, which is responsible for developing user interfaces that will facilitate the interaction of end users with their iFLEX Assistants.

1.1 Purpose, context and scope

Based on the agile approach of the iFLEX project, there will be three deliverables on Natural User Interfaces, namely D3.4, D3.5, and D3.6, corresponding to the three phases of the project's implementation. The current document, D3.4, has two main objectives:

- To serve as the guide for the development process of the User Interface components of the iFA. Towards that goal, a detailed list of requirements concerning the User Interface is documented with the focus lying primarily on Phase 1;
- To facilitate quick integration between different components of the iFA. Hence, existing solutions and up-to-date progress on the User Interface components is documented as a base.

1.2 Content and structure

Addressing the main objectives of the project's tasks contributing to this report and its audience, this document is structured as follows:

- Chapter 1 (the present section) is an introductory chapter for the report;
- Chapter 2 describes the adopted methodology for documenting the design of the User Interface (UI) component, the project's approach on co-creation with end users, and pilot-specific design considerations at a high-level;
- Chapter 3 provides an overview of the iFLEX solution, the User Interface and the focus of the first development phase;
- Chapter 4 presents the existing solutions related to the User Interface in the different pilots;
- Chapter 5 provides the documentation of implementation aspects of the solution, taking into account different system architecture views, and initial design of the User Interface;
- Chapter 6 concludes the report with main outcomes and future steps.

2 Methodology and approach

This chapter describes the methodology followed for the design of the user interface solutions. Initially, the general iFLEX design approach is presented. Then, a closer look to the concept of co-creation with end users is exhibited, due to its importance for the project. Finally, pilot-specific design considerations are elaborated.

2.1 Overview

The design of the iFLEX Assistant follows a user-centred design approach with the intention to make it easy for (residential) energy consumers to participate in demand response and with a focus on framing a good user experience of the iFLEX solution (visit D2.1 [1] for more information on the user experience approach).

The user-centred design process is shown in Figure 1. The process consists of a series of steps with methods applied, planned or suggested at each step.

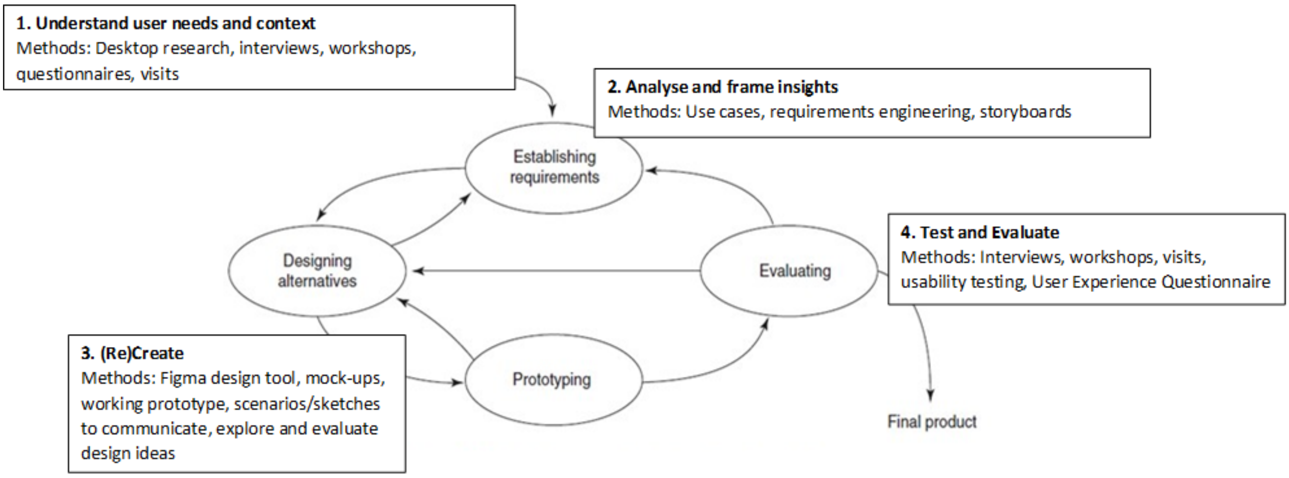

Figure 1: iFLEX design process model using 'A simple interaction design lifecycle model' by [2], p. 332, fig. 9.3

The first step (1) is to understand the users, who are targeted by the project, as well as their context. In iFLEX, focus is laid mainly on (residential) energy consumers, since these users interact directly with the iFLEX Assistant. Knowing the needs and context of other stakeholders is also relevant, since these stakeholders influence and are influenced by the usage. The context refers to both societal aspects and the environment in which the iFA is interacted with. Understanding the user is particularly important in the case of determining what constitutes a 'natural' interface. Initially, user and context insight has been gained through desktop research and workshops with expert stakeholders. A 'real' user research will take place as soon as the pilot participants are recruited.

After the research phase, the data are organised, analysed and translated into insight, framed by use cases, requirements and storyboards (step 2). The use cases, design principles and requirements have been analysed in the public document D2.1 - Use cases and requirements [1]. More detailed requirements, which are focused on the User Interface, are documented in the Appendix (Section 9.1) of the present deliverable. A storyboard (see Section 3.4, Figure 4) has also been used to summarise the requirements relevant to the 1st phase and highlight the interrelations between these requirements. This work has served as a guideline for the design of the initial iFLEX mock-ups.

The next step (3) is the move from understanding to creating. Here, different design ideas are tried out and manifested through prototyping with the aim to communicate, co-create and get feedback on the concepts. Presently, mock-ups, which have been designed with the Figma tool[1], are used (see Section 5.4), as well as scenario sketches to communicate the iFLEX concept, functionalities and integration aspects (see Sections 5.1 to 5.3). To cover the experiential aspect of engaging with the Assistant, iFLEX aims at an active audience participation and hands-on experience so as to enable users to 'experience it themselves' ([3], p. 425).

[1] Figma design tool: https://www.figma.com/design/

Testing and evaluation of the design ideas are part of step 4 with specific methods that address the complete user experience, covering aspects in terms of usability, usefulness and pleasure based on what the users say but also on what they do. Methods used here include usability testing and User Experience Questionnaire, as in the sample provided in [4]. So far, interviews with pilot partners have been conducted, during which the initial UI features and design were presented, so that the partners could provide the designers with their feedback on them. This feedback has been considered in order to proceed to the first adjustments of the UI design and populate a list of possible alternatives on various features of iFA. Furthermore, a questionnaire (see Section 9.2) has been prepared, to be distributed to all the project partners, so that they can also submit their feedback on the UI design and user experience overall. Within the context of co-creation with end users, interviews with pilots' actual users are planned to receive feedback from external stakeholders.

As illustrated in Figure 1, the process is iterative with the option of revisiting single or several steps if needed. In iFLEX, the iterations will result in three overall outputs in M8 (this deliverable), M18 (D3.5) and M30 (D3.6).

2.2 Design Documentation

The methodology employed for documenting the design is based on the Viewpoints and Perspectives framework [5] and ISO/IEC/IEEE 42010:2011 "Systems and Software Engineering – Architecture Description" [6]. According to the concept described in these references, an architecture description can be organised in different views using viewpoints. Thus, separation of concerns among stakeholders can be achieved through different viewpoints, whilst the description of the whole system is still provided, as this is essential to the notion of system architecture. A viewpoint is a collection of patterns, templates, and conventions for constructing one type of view. It defines the stakeholders whose concerns are reflected in this viewpoint and the relevant guidelines, principles, and templates for constructing, presenting and analysing views. A view is a representation of a whole system from the perspective of a related set of concerns. It defines the architecture of the under-analysis system based on a particular viewpoint.

The following views are documented in this deliverable:

- **Context:** A high-level architecture detailing interactions of the User Interface. This view introduces the main interactions of the UI component with its environment, namely the iFA end user and other components of the solution;
- **Functional:** The functional specification of the system, focusing on the UI component and its responsibilities and primary interactions with other components of the Assistant and the end users. The description of the functional view is based on the foundations of the Use Case (UC) Analysis, which was documented in D2.1 [1]. In that deliverable and considering the UC hierarchy, several Secondary Use Cases (SUCs) were identified. The SUCs that are relevant to the UI component within the first phase of the project are analysed in the current document via sequence diagrams and explanatory tables. These SUCs are also linked to the detailed UI-related requirements that were elaborated on the basis of the UC Analysis and are documented in the form of User Stories in Section 9.1. The User Stories, which are applicable to the first iteration of the project, are depicted in the storyboard, which is presented in Figure 4 (Section 3.4). This storyboard provides a concise summary of individual user stories, as well as potential interrelations between them;
- **Information:** A static view of information objects relevant to the UI component. This view can serve as common ground for data flows exchanged between components developed by various project partners.

2.3 Co-creation Process

The development process of iFLEX consists of three iterations. The goal of Phase 1 is to co-create and validate a Minimum Viable Product (MVP) of the iFLEX Framework and application-specific iFLEX Assistants and deploy them into a pre-pilot consisting of few selected users in order to collect feedback and validate against the functional requirements. In Phase 2, the feedback from Phase 1 is utilised to improve the iFLEX Framework with new functionalities and better user experience. At the end of this phase, the improved iFLEX Framework and Assistants developed on top of the framework have been validated with small-scale pilots. In Phase 3, any missing functionality is added, and the focus is then on fine-tuning the quality of service (QoS) and user experience based on the Phase 2 feedback. At this phase the pilots are also scaled up in order to collect feedback and validate the Final iFLEX Assistants in large-scale.

Co-creation activities with pilot users for the UI design will be most intensive at the beginning of each phase, where planning and design take place, as shown in Figure 2.

Figure 2: iFLEX agile development process – 3-phase pilot delivery

Each co-creation activity will consist of minimum 4 steps:

1. **Users On-boarding** (Recruitment Procedure, Inclusion/exclusion criteria, Informed Consent Procedure, Ethics checklist)
2. **Preparation** (prepare educative and awareness materials for pilot users related to UI, prepare presentations, prepare questionnaires, prepare visualisations and communication, prepare initial UI mock-ups and design ideas, prepare workshops)
3. **Co-Creation** (workshops, brainstorming, questionnaires, elicit requirements)
4. **Evaluation** (evaluate co-creation results, provide inputs for design)

Pilot users from all 3 pilot clusters will be involved (Greek, Slovenian, Finnish) into the UI co-creation process. Depending on the existing solution, baseline data and types of pilot users, each pilot cluster is planning co-creation activities based on [7]**,** which are centrally documented, coordinated and monitored in an online document that is accessible to all iFLEX partners via the project's private repository.

Methods used for co-creation activities, as defined in [7], include the following: Desk research, Workshop (focus group), Contextual interview and observation, On-line survey, Review of a deliverable or a partial deliverable, Field trial (evaluation), In-app analytics, User personalisation.

2.4 Design considerations

This section presents pilot-specific design aspects, which are relevant to the User Interface component, that were considered during this work related to existing solutions.

The development of the User Interface component of the iFLEX Assistant focusing at individual end users – which will be tested with actual users in Greek and Slovenian pilots - is led by ICOM, acting as the main responsible solution provider. Specificities related to pre-existing solution in the Greek pilot, developed by HERON, were considered during the design phase, focusing on smooth integration with the developed solution within the iFLEX project. HERON's existing interface is mainly related to energy monitoring, whilst user interfaces of iFLEX project will accommodate a variety of needed features, as identified during requirements engineering phase.

Regarding the solution of iFLEX Assistant UI in the case of building communities – which will be tested in the Finnish pilot – the main consideration is the existing solution developed in the context of the "Making City" [8] project, which will serve as a basis.

The existing solutions considered during the preparation of this work are further elaborated in Chapter 4.

3 Overview of the iFLEX solution

The goal of T3.3 is to develop user interfaces that will facilitate the interaction of end users with their iFLEX Assistants in a natural way. The users should be equipped with the ability to:

- Provide their preferences and constraints;
- Monitor their energy consumption and generation;
- Receive tailored energy advice;
- Gain insights into their participation in flexibility services;
- Monitor their energy costs;
- Opt for the preferred level of autonomy of their Assistant;
- Provide their iFA with feedback on its operation.

3.1 End Users

The potential end users of the system under development should be considered during the design process, so that appropriate requirements are elicited. The solutions related to T3.3 concern iFA end users, who could be further classified into two categories:

- **Individual end users**: The residents of the premises, which are managed by iFA. These users aim to exploit the functionalities of iFA to accomplish their economic or environmental objectives and interact with the Assistant via the User Interface (UI) component;
- **Facility managers**: This type of iFA end users is responsible for the management of a group of premises, as in the case of apartment or commercial buildings. Their motives are economic and pursue to gain profit through offering the aggregated flexibility of their establishment(s) to the energy and flexibility markets. The interaction of these users with their iFA is enabled via the User Interface as well.

3.2 Relation to Requirements

The main interactions of iFA with external systems and end users were analysed in the form of High-Level Use Cases (HLUCs) and Primary Use Cases (PUCs)[2] during the process of requirements' elicitation of task T2.2. As documented in D2.1 [1], all the identified HLUCs and PUCs of the project concern the UI component, whilst a set of User Stories is also documented for capturing end user's viewpoint. On the basis of this initial analysis, more detailed requirements concerning the UI component were elaborated in the form of User Stories – most focusing on the user's experience with iFA – and are documented in the Appendix (Section 9.1) of this report.

3.3 Relation to iFLEX Framework architecture

The iFA solution aims at enabling Consumers and/or Prosumers at the level of individual premises, or at the level of a community to improve the energy and sustainability performance of their premises and enter the energy and flexibility markets by offering demand side flexibility services to relevant market actors.

A functional viewpoint for the iFA is presented in Figure 3, where the focus of T3.3 activities and correspondingly of the UI component is highlighted.

[2] For information on use case terminology the reader should refer to D2.1.

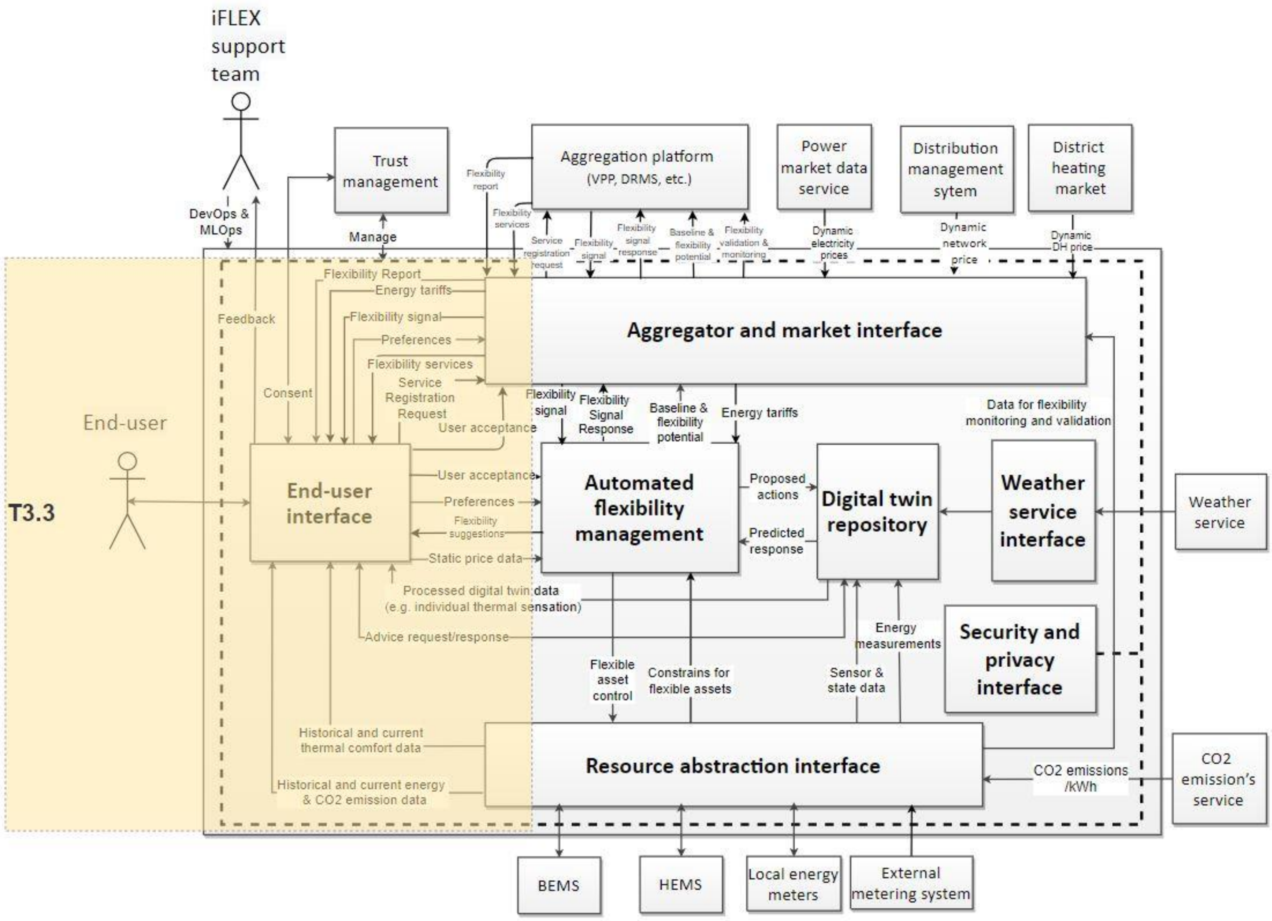

Figure 3: Functional view of the common iFLEX Framework [9]

The UI component enables the interaction of the end users with iFA. A key feature of the solution is to capture user preferences and constraints, which should be considered by iFA while managing the energy and flexibility of the premises. Furthermore, it provides the end users with the ability to gain deeper insights into their energy data, energy tariffs, and their participation in flexibility actions, as well as in the respective remuneration for their engagement in offering flexibility services. Enabling the end users to have control of iFA processes, the UI component enables parameterising the desired level of autonomy and customise their interaction with it. Finally, component enables the iFLEX support team to receive direct feedback from the pilot users, with the aim to improve the under-development system considering their views and potential concerns.

As regards the interactions of the UI component within the iFA, the interfaced components are the Aggregator and Market (A&M) Interface, the Automated Flexibility Management (AFM), the Digital Twin Repository (DTR), and the Resource Abstraction Interface (RAI). The exchanged data with the A&M Interface are important for the clear and timely information of iFA end users regarding flexibility services and energy market data, as well as for responding to Demand Response (DR) events. The information flow between the UI and the AFM component concerns the provision of user preferences and constraints, as well as the iFA-suggested schedules for flexible assets and the user’s response to them. Furthermore, the users might be able to add themselves their energy tariffs in iFA – depending on the specificities of each pilot. As regards the interaction of the UI component with the DTR, processed data (e.g. with respect to individual thermal sensation) and signals related to the energy advising service of the Assistant shall be exchanged. Lastly, the UI should be able to receive real-time and historic energy and thermal comfort data from the RAI. More information on these functionalities is provided in Section 5.2.

3.4 First phase focus

Deliverable D7.1 [10] has defined the initial specifications to be demonstrated in the three pilot clusters (i.e. Greece, Slovenia and Finland) during Phase 1 (pre-pilot), where the aim is to develop a Minimum Viable Product (MVP) of the iFLEX Framework and Assistants and demonstrate the iFLEX solution with a small number of users.

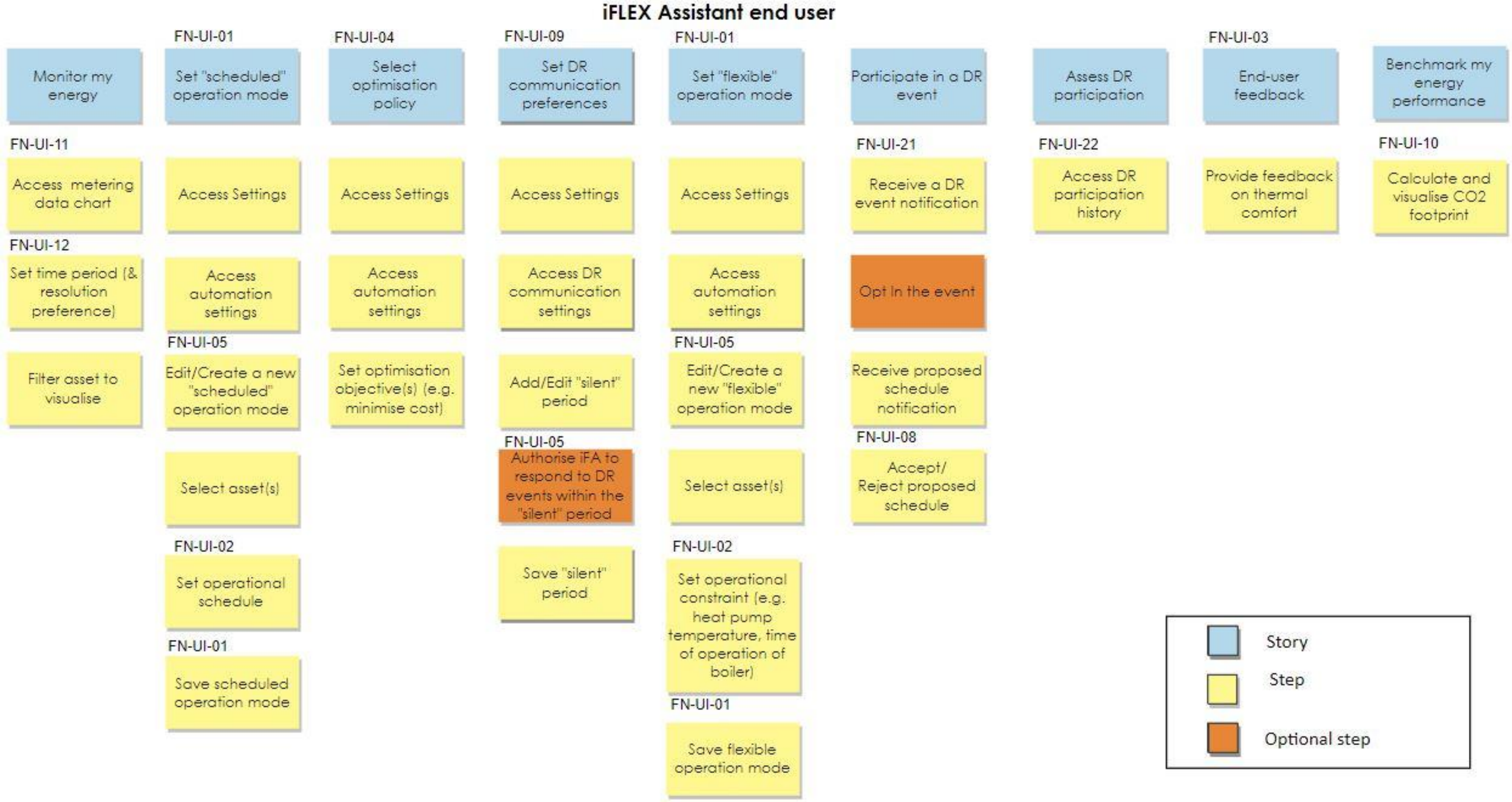

Figure 4: Storyboard for the iFA end user (Phase 1)

Each pilot has identified some concrete objectives as well as activities that will be carried out during this phase. The purpose of this section is to summarise the requirements those related to the UI component, as prioritised for implementation during Phase 1.

A summary of the requirements of this phase are presented in the form of a storyboard in Figure 4. The iFA end users should be able to monitor their real-time (FN-UI-11) and past energy data (FN-UI-12). In addition to that, they should be equipped with the ability to choose their desired level of automation (FN-UI-05) by customising and activating scheduled and flexible operation modes (FN-UI-01). While editing these modes, the users shall be able to provide the Assistant with their time and operational constraints (FN-UI-02). Furthermore, the users should be able to provide feedback on their thermal comfort (FN-UI-03) and gain insights into their sustainability metrics (FN-UI-10). As regards the DR-related functionalities of the UI, the mobile app should provide the pilot users with the ability to set specific time periods in which DR notifications are not allowed (FN-UI-09). Moreover, DR event notifications (FN-UI-21) shall be presented to the users, who should be subsequently asked to grant their consent for the system-proposed schedules for their flexible assets (FN-UI-08) – provided that this is enabled by the user-defined DR notification policy. Finally, the users should be able to access their DR participation history (FN-UI-22). For a more detailed presentation of the requirements please check Section 9.1.

3.4.1 Greece

During the first phase of the Greek pilot, the users will be able to monitor their real-time (FN-UI-11) and past energy data (FN-UI-12). Furthermore, they will be equipped with the ability to choose the level of automation (FN-UI-05) by customising and activating scheduled and flexible operation modes according to their will and preferences (FN-UI-01). While editing these modes, the users will be able to provide the Assistant with their time and operational constraints (FN-UI-02). As regards the DR-related functionalities of the UI, the iFA will provide its users with the ability to set preferences of DR notifications (FN-UI-09). Furthermore, DR event notifications (FN-UI-21) will be presented to the users, who will be subsequently asked to provide their consent for the system-proposed schedules for their flexible assets (FN-UI-08). Finally, the users will be able to inspect their DR participation history (FN-UI-22) via their mobile app.

3.4.2 Slovenia

The first phase of the Slovenian pilot shall enable users to get insights into their past energy data (FN-UI-12). Users shall also be able to configure specific time periods in which they do not want to be disturbed with DR notifications (FN-UI-09). Outside of these time periods, the users shall be notified of the new upcoming DR event(s) (FN-UI-21).

3.4.3 Finland

Phase 1 of the Finnish pilot monitors electricity and district heating consumption on building level (FN-UI-11, FN-UI-12). All residents have access to their own building data with a specific web-application. The CO_2 footprint is also calculated for consumed energy using useful information and data related to electricity generation (FN-UI-10). Users can give feedback anytime about their thermal comfort with 7-scale rating input and free text input (FN-UI-03). Registered users have a possibility to have thermal sensors installed in their apartment, measuring temperature and humidity. Registered users can view their own apartment’s thermal data and their feedback on thermal comfort is addressed to their own apartment. As regards other residents' feedback, this concerns the common areas of the building. Facility manager has access to building-level data via dashboard views.

4 Existing solutions

This chapter presents existing solutions related to the User Interface, which will serve as bases for the iFLEX project in the various pilots. First, the existing solution for the Finnish building community is presented, which is based on “Making City” [8], a large-scale demonstration project aiming at the development of new integrated strategies to address the urban energy system transformation towards low carbon cities, using the Positive Energy District (PED) approach. Then, HERON’s Real-time Energy Metering and Actuation Platform, which will be integrated into the Greek pilot, is described.

4.1 Building Community: Making City - Positive Energy Districts

The User Interface is a web application accessed by the user through a web browser with an active internet connection. It is written with JavaScript[3], HTML[4], SVG[5] and CSS[6]. It utilizes modular programming techniques facilitated by ECMAScript 6[7] (ES6) and MVC[8] and observer patterns. It is made with Responsive Web Design[9] (RWD) approach, so it naturally supports different devices: smartphones, tablets, laptops and desktops, as shown in Figure 5.

Figure 5: The user interface supports naturally different devices.

The user interface can be divided into public and private sections. The public section contains information about solar energy, environmental load of energy used and aggregated load from grid. Also PED area buildings and PED-level metrics are visualised to detail suitable data for unauthenticated users (Figure 6). The private section contains residents’ apartment data, and it is for authenticated users only.

The power and energy data for each component is stored at a dedicated measurement server. The user interface fetches and visualises measurement data periodically using user-defined interval (default is 30 seconds). At building level visualisation, energy flow direction is visualised using animation. At chart level visualisation, each component can have several subcomponents plotted into the same chart (Figure 7).

[3] About JavaScript: https://developer.mozilla.org/en-US/docs/Web/JavaScript/About_JavaScript
[4] What is HTML?: https://www.w3schools.com/html/html_intro.asp
[5] What is SVG?: https://www.w3schools.com/graphics/svg_intro.asp
[6] What is CSS?: https://www.w3schools.com/css/css_intro.asp
[7] Overview of ECMAScript 6: https://262.ecma-international.org/6.0/#sec-overview
[8] Model View Controller pattern: https://en.wikipedia.org/wiki/Model-view-controller
[9] Responsive Web Design – Introduction: https://www.w3schools.com/css/css_rwd_intro.asp

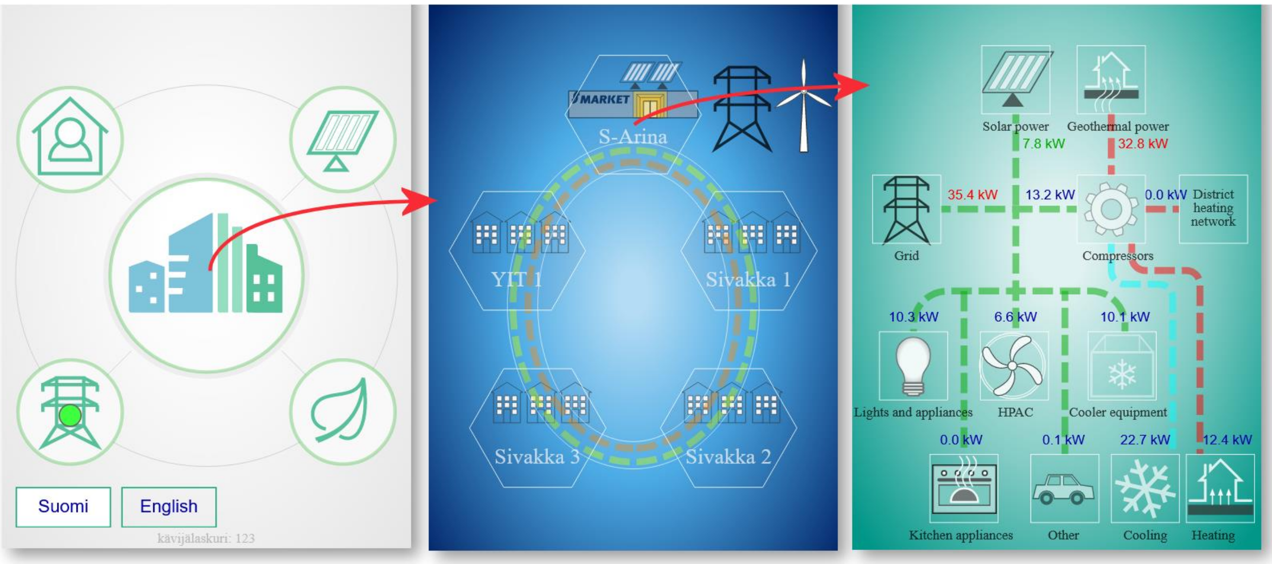

Figure 6: Main menu, public PED area buildings and S-Market.

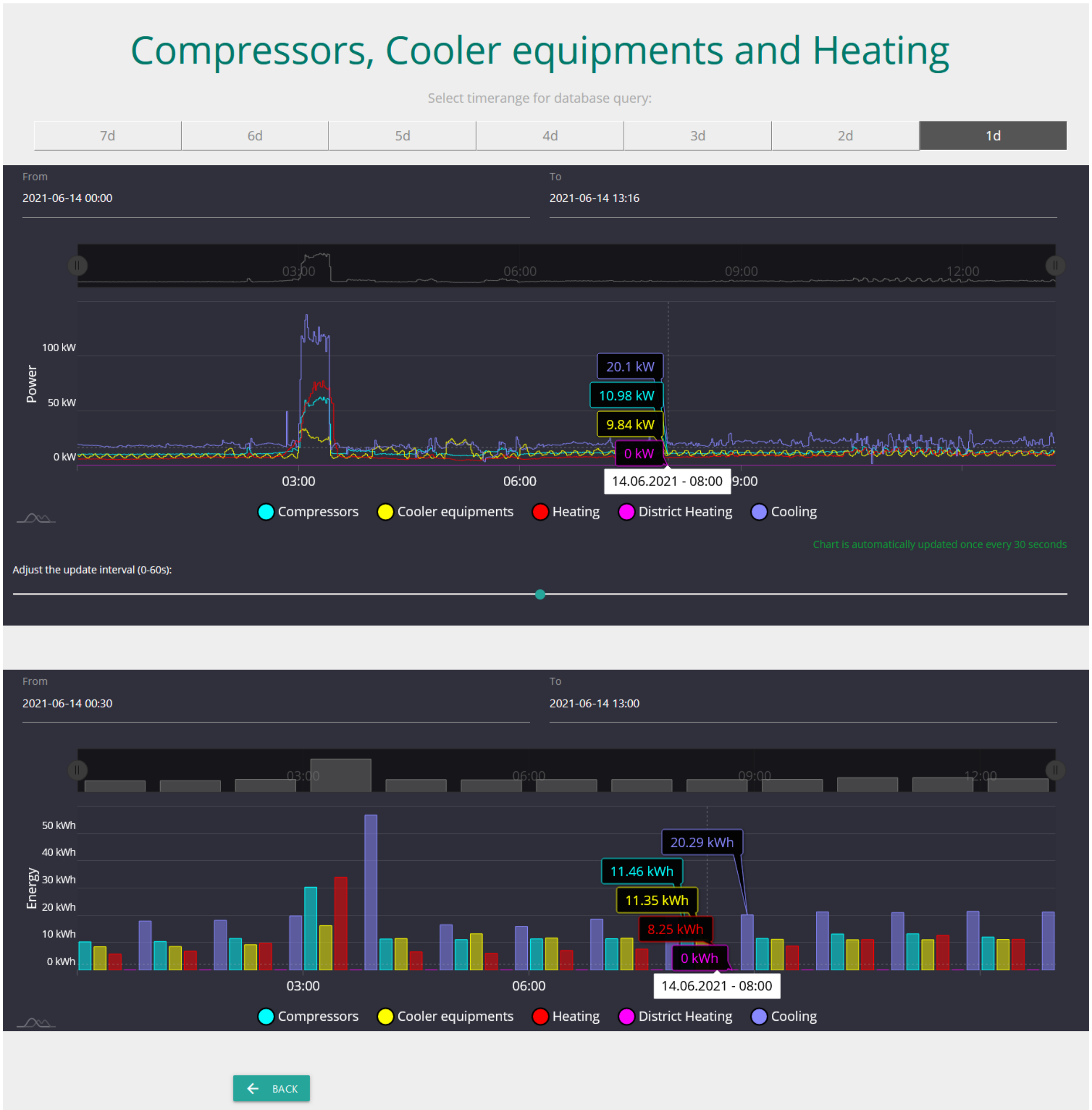

Figure 7: Cooler equipment contains five subcomponents.

The private section visualises apartment data for logged-in users. This includes electricity consumption, heating conditions (temperature and humidity) and water consumption.

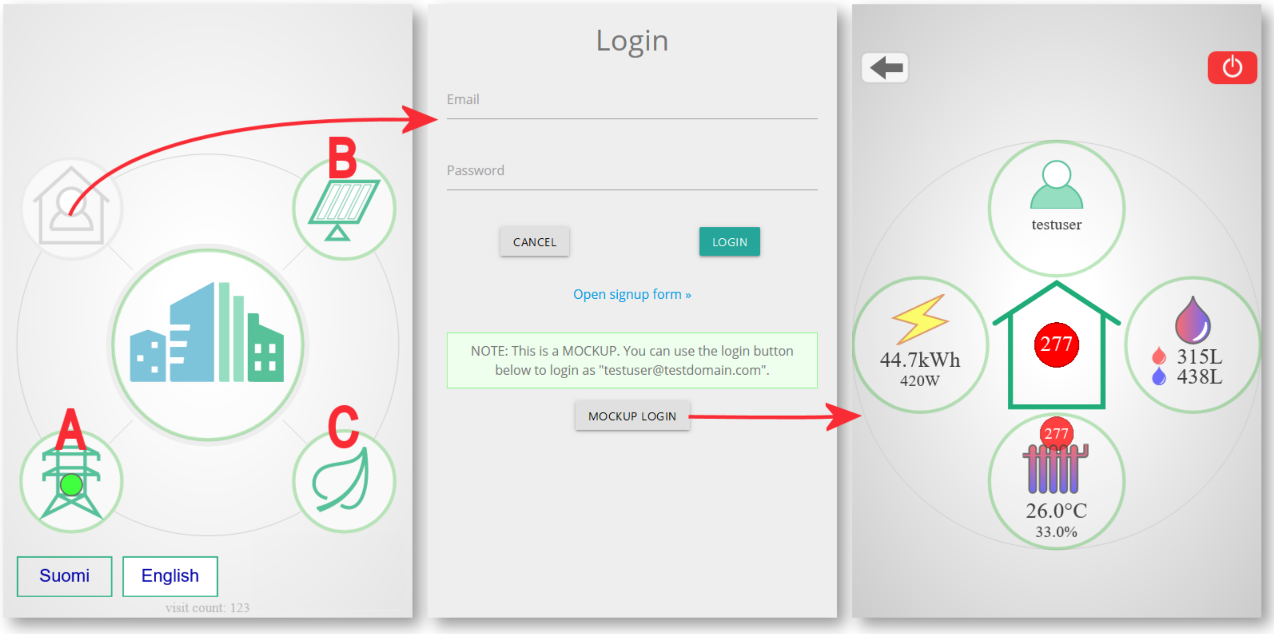

Figure 8: User login to view apartment data.

Grid status (**A**), solar energy forecast (**B**) and CO_2 emissions (**C**) (Figure 8) are calculated from energy production and consumption data in Finland. Data is fetched from multiple open-data platforms (Fingrid, ENTSO-E, etc.) and when calculating emissions, energy import from Sweden, Norway and Russia is also taken into account.

At user properties view, user can adjust different energy price components: fixed monthly price, energy price and network price, which are used to calculate electricity charges per day, week and month, according to the respective consumption measurements (Figure 9).

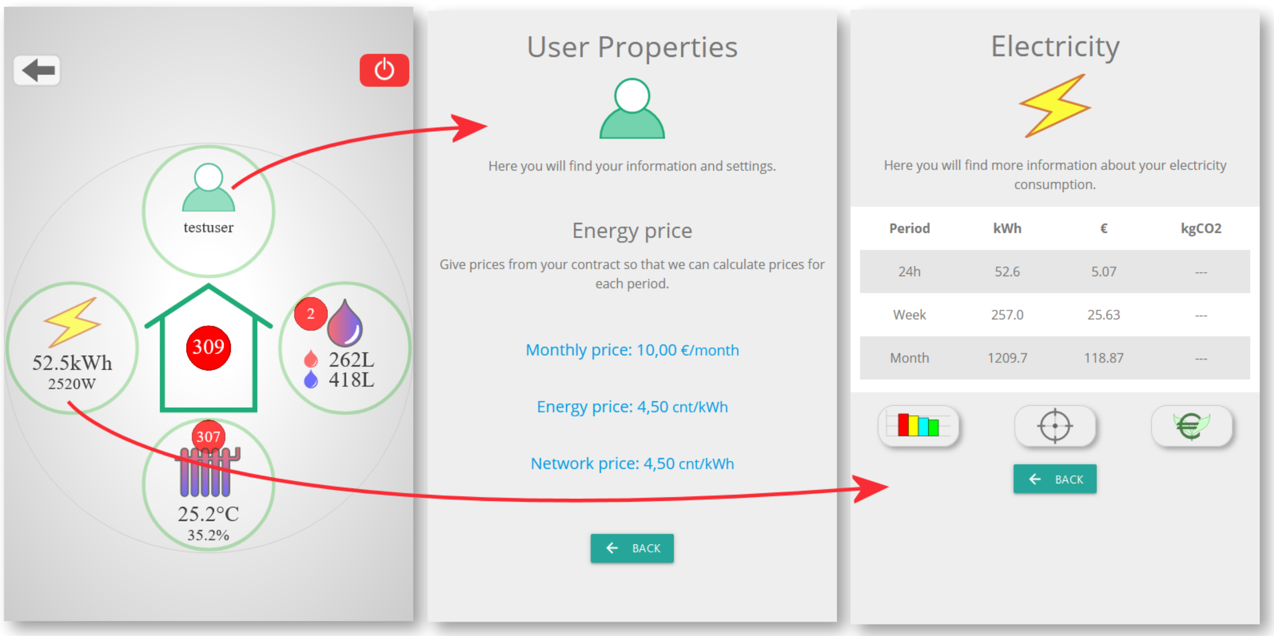

Figure 9: User can input energy prices.

4.2 Individual Resident: REMAP

4.2.1 Overview

Real-time monitoring of consumer consumption requires the deployment of accurate hardware metering products at user premises, along with an accompanying back-end platform for measurement collection, storage, visualisation and access. HERON operates an integrated platform consisting of software and hardware systems for energy monitoring and management, the Real-time Energy Metering & Actuation Platform (REMAP). The system includes:

- Smart meters: Wi-Fi meters installed at the electrical board of residential consumers to collect consumption data in real-time and support remote activation of relays driving heavy appliances (e.g., water heaters)
- Administrator & User management dashboards: Web-based dashboards to enable consumers to access their historical consumption data as well as HERON administrators to analyse the aggregated consumption of connected consumers.
- HERON's web API: A remote API to provide access to external parties and services.

The existing Wi-Fi network of the end user is used to communicate over the Internet with the cloud server. The various cloud services support collection, storage and visualisation of metering data. The overall system allows for simultaneous connection by the: a) system administrator over web dashboard, b) end consumers for monitoring own consumption, and c) 3rd party services communicating over a well-defined remote API. The overall energy metering platform architecture is presented in Figure 10.

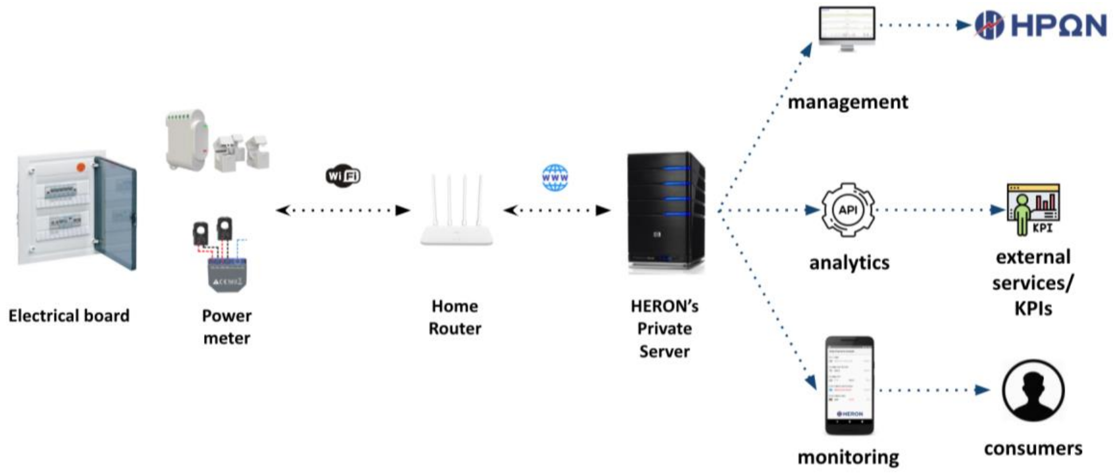

Figure 10: Architecture of REMAP

Integration with external components (smartphone application, web dashboard, analytics agents, etc.) is enabled through the exposed web REST API. In this context, we consider that all interactions with the iFLEX project, will employ the existing REST API, requiring of course adaptation and extensions. The list of monitored parameters, along with the relevant measurement unit and collection interval are analysed in the following table.

Table 1: List of monitored parameters by the HERON energy metering platform

Monitored Parameters	Unit	Interval
Active Power	Watts	**30 sec**
Voltage	Volts	**30 sec**
Energy	kWh	**5 min**
Reactive Power	Watts	**30 sec**
Power Factor	-	**30 sec**

4.2.2 User Dashboard

Indicative screenshots of the user dashboard presenting the energy consumption analysis along with indicative energy data of individual connection points are illustrated in the following figures. The system considers as input a fixed tariff per kWh for end users for all cost calculations. Individual tariffs per connected consumer can also be considered as input to provide customised billing analysis per connected consumer.

Figure 11: Daily consumption view of user web-based dashboard

Figure 12: Daily consumption view of user dashboard

Figure 13: Monthly consumption analysis versus cost

4.2.3 Admin Platform

Upon the connection of a new energy meter device, new user dashboards are automatically generated and appear as available on the REMAP admin platform (Figure 14). The administrator then needs to assign each connected meter to the respective end user/consumer. The respective procedures of meter and user management are illustrated in Figure 15 and Figure 16 below.

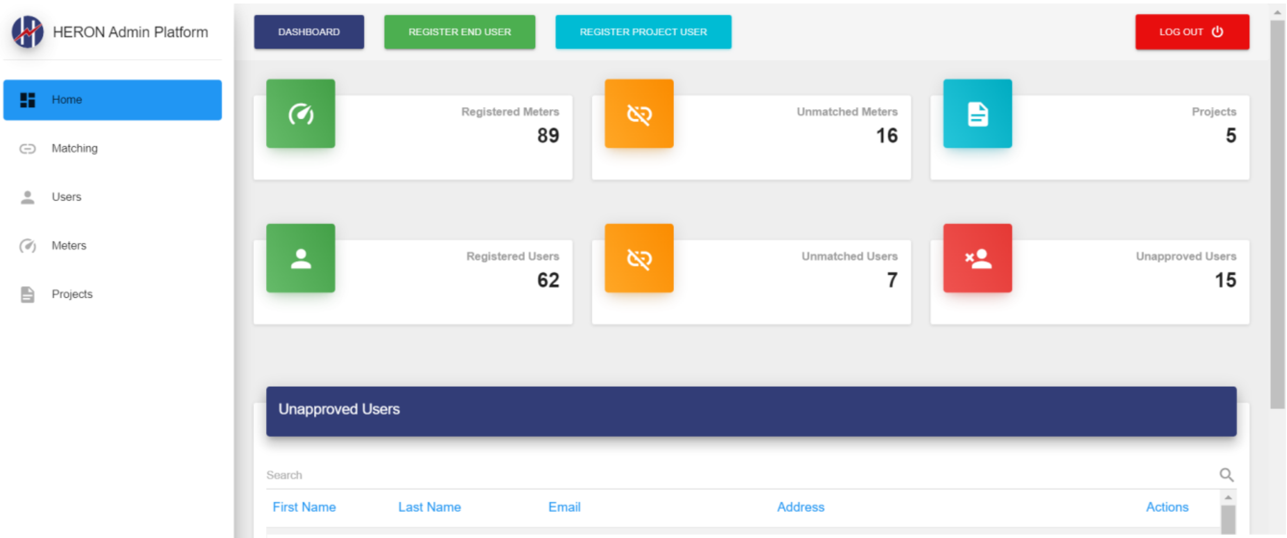

Figure 14: REMAP admin dashboard

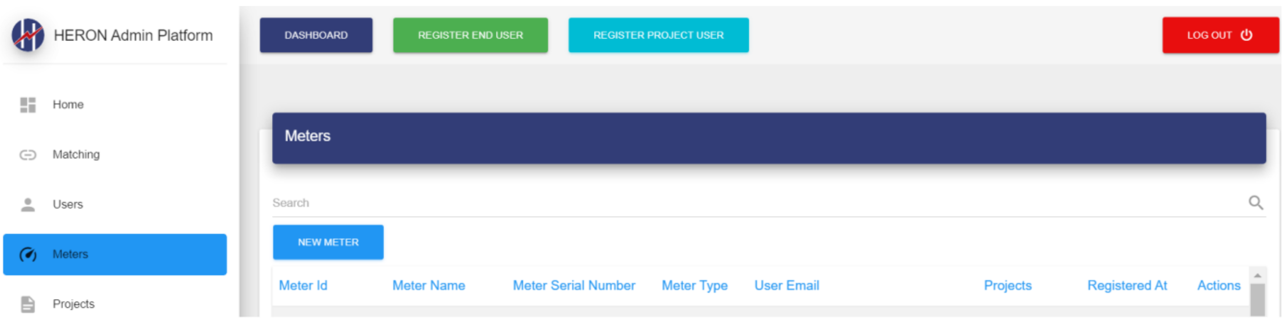

Figure 15: Meter management interface

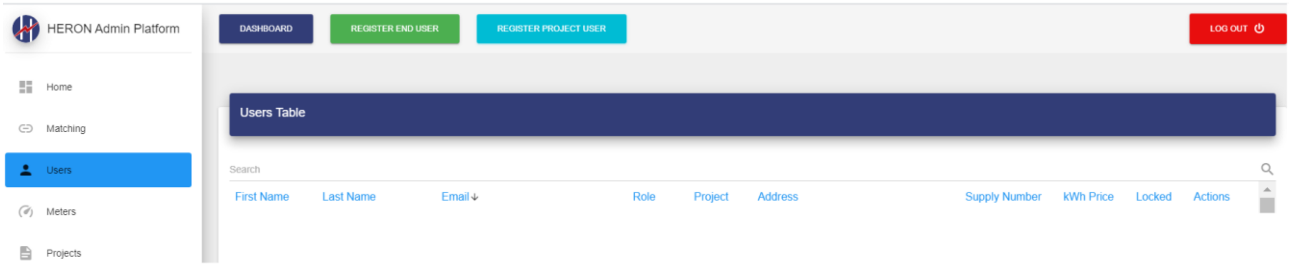

Figure 16: User management interface

4.2.4 Alerting mechanism

Meters might occasionally disconnect from the central platform, due to user actions (e.g. change of Wi-Fi password, change of router position). In this case, the alerting mechanism is activated to detect meters that did not submit a new measurement over a specific interval (e.g. 5 minutes), it then generates a notification on the administrator dashboard and automatically sends an email to the specified list of emails.

Figure 17: Alerting mechanism

5 Implementation

This chapter concerns the implementation for the Natural User Interfaces task (T3.3), so the focus lies on the UI component. First, the architectural views – namely context, functional, and information views – on the User Interface are described. Then, the conducted work with respect to the UI design is presented.

5.1 Context View

This section presents a high-level view of the UI component. In this initial phase the iFA UI component was considered as a mobile application that will provide the end-user with the following functionalities:

- Monitor energy consumption/generation within premises;
- Choose their desired level of automation by customising and activating scheduled and flexible operation modes - providing time and operational constraints;
- Provide feedback on their comfort level;
- Gain insights into their sustainability metrics;
- Set preferences on DR notification policy and system-proposed schedules for their flexible assets;
- Access their DR participation history.

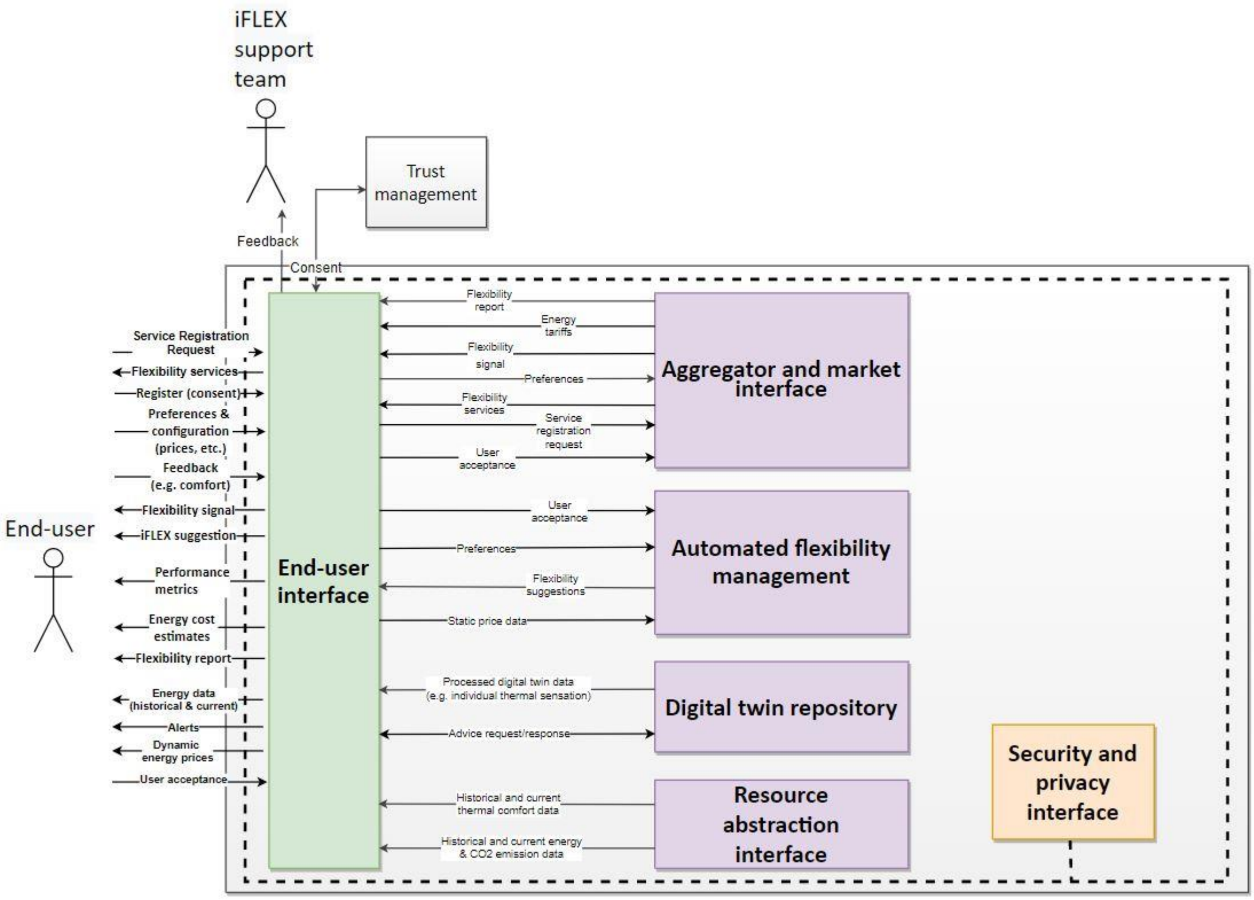

Figure 18: Context view of User Interface Component

Towards this, the UI component will need to communicate with the various components of the iFA Framework:

- Aggregator and Market Interface (A&M Interface): The information flows with the A&M Interface concern DR-related signals, such as receiving information on available flexibility services, flexibility signals and flexibility reports, and responding to flexibility signals or subscribing to a new flexibility service. In addition to that, energy tariffs are communicated to the iFA end user via the UI module.

- Automated Flexibility Management (AFM): The AFM module receives from the UI the user preferences with respect to the operation of flexible assets. Furthermore, the iFLEX-suggested schedules are communicated from the AFM to the UI module, which in turn provides the AFM with the user's response to a suggestion. Finally, the users might be able to add themselves their energy tariffs in iFA via the UI, and inform the AFM about them – depending on the specificities of each pilot.
- Digital Twin Repository (DTR): As regards the interaction of the UI component with the DTR, processed data (e.g. with respect to individual thermal sensation) and signals related to the energy advising service of the Assistant shall be exchanged.
- Resource Abstraction Interface (RAI): The UI module should be able to receive real-time and historic energy, CO_2 emission, and thermal comfort data from the RAI.

Figure 18 presents the interactions of the UI component with its environment, namely the iFA end user and other components of the iFA. It is highlighted that this context concerns the full lifecycle of the iFLEX project and not only Phase 1.

5.2 Functional View

In this section, the features of the UI component of the iFA are elaborated via sequence diagrams and concise tables summarising key facts per Use Case (UC). The UCs presented here are of lower level and – considering also the UC hierarchy identified in D2.1 – are defined as Secondary Use Cases (SUCs). In addition to the SUCs presented in this section, some additional requirements for the UI module stem from SUCs detailed in D4.4 [11]. These SUCs concern communicating flexibility signals, energy tariffs, and new flexibility services to iFA end users, as well as enabling the users to subscribe to a flexibility service via their Assistants. The reader is referred to D4.4 for more details. As regards the sequence diagram presented in this section, the exchanged data between iFA's components comply with the iFLEX data model (see Section 5.3 for more details). The solid and dashed arrows stand respectively for synchronous and return messages, according to the conventions of the Unified Modelling Language (UML)[10] on sequence diagrams [12].

5.2.1 SUC-9: Access real-time energy data

The iFA end users should be equipped with the ability to access their energy data in real-time upon request, so that they can have a clear view of their total energy consumption and potential generation, as well as insights into specific assets.

Once the end user accesses the metering data chart via the UI, energy data are retrieved from the RAI. Subsequently, the data are visualised in the UI component and presented to the end user. The steps can be seen in Figure 19.

[10] The Unified Modelling Language: https://www.uml-diagrams.org/

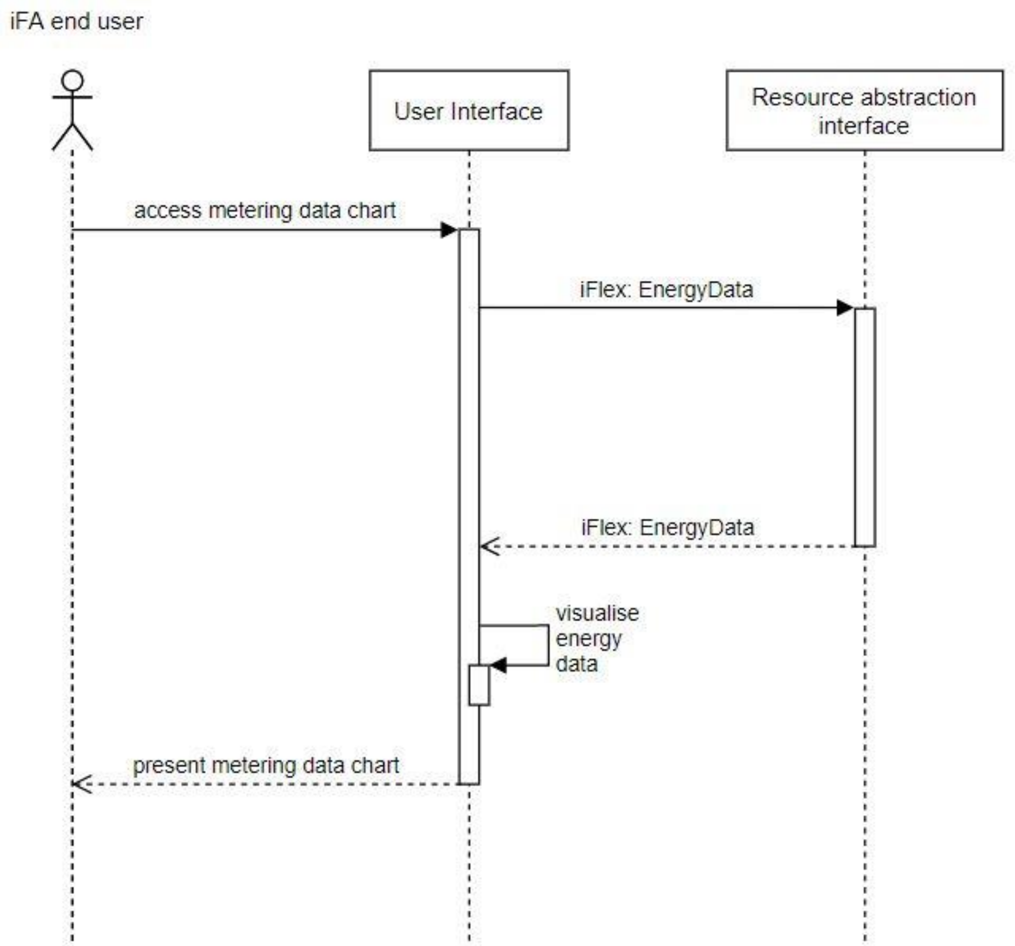

Figure 19: Sequence diagram of SUC-9 - Access real-time energy data

Table 2: SUC-9 - Access real-time energy data

SUC-9	Access real-time energy data
Related PUC	PUC-7 - Monitor my energy in real-time
Related requirements	FN-UI-11 - Real-time energy data
Brief description	iFA end users can access their real-time energy data upon request.
Assumptions	1. The iFA is parameterised and fully operational. 2. The requested data are available.
Preconditions	-
Postconditions	The iFA end user can access energy data.
Relevant pilots	Finland, Greece, Slovenia

5.2.2 SUC-10: Define optimisation policy

The iFA end users can define the optimisation policy for their premises, so that the operation of the Assistant complies with their objectives. Minimisation of energy costs or minimisation of CO_2 emissions could be among the possible objectives.

The end users can select their preferred optimisation objectives upon accessing the relevant page of the UI. Then, their choices are communicated by the UI to the AFM component. Thus, the objectives of the users are considered while devising the scheduling optimisation of the flexible assets. The procedure is presented in Figure 20.

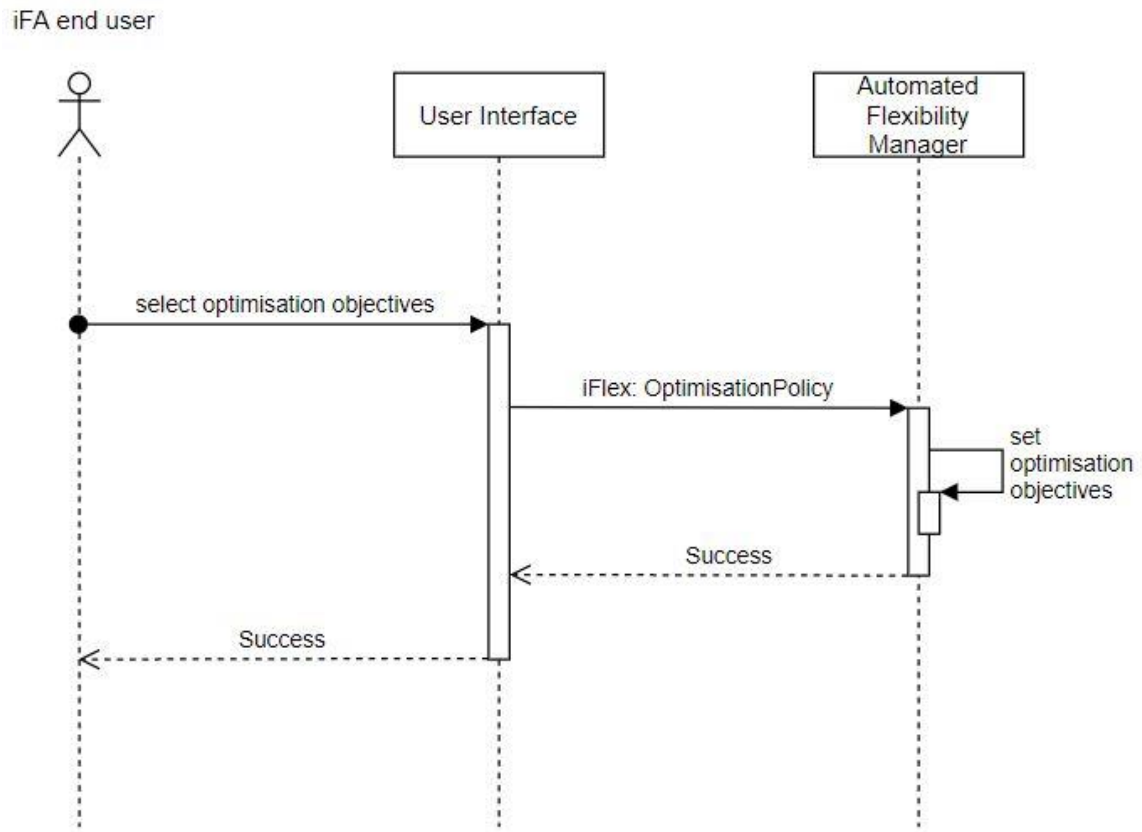

Figure 20: Sequence diagram of SUC-10 - Define optimisation policy

Table 3: SUC-10 - Define optimisation policy

SUC-10	Define optimisation policy
Related PUC	PUC-1 – Manage my preferences
Related requirements	FN-UI-04 - Optimisation policy selection
Brief description	iFA end users can select their optimisation objectives.
Assumptions	The iFA is parameterised and fully operational.
Preconditions	-
Postconditions	Optimisation policy is saved. iFA takes into account the user's selected optimisation policy while devising the schedules of flexible assets.
Relevant pilots	Greece, Slovenia

5.2.3 SUC-11: Grant acceptance to schedules

The end users should also be able to review iFA-suggested schedules for flexible assets, in case they prefer the manual operation of the Assistant.

Following the calculation of a schedule by the AFM component, the suggested schedule is communicated to the UI, which sends a notification to the iFA end user. The user's response is added by the UI component in the DR participation history and sent to the AFM component. If the user accepts the schedule, the procedure ends. In case of rejection, this procedure is repeated for a maximum number of times (e.g. 4) - provided that alternative schedules exist - prior to abandoning the process. The procedure is shown in Figure 21.

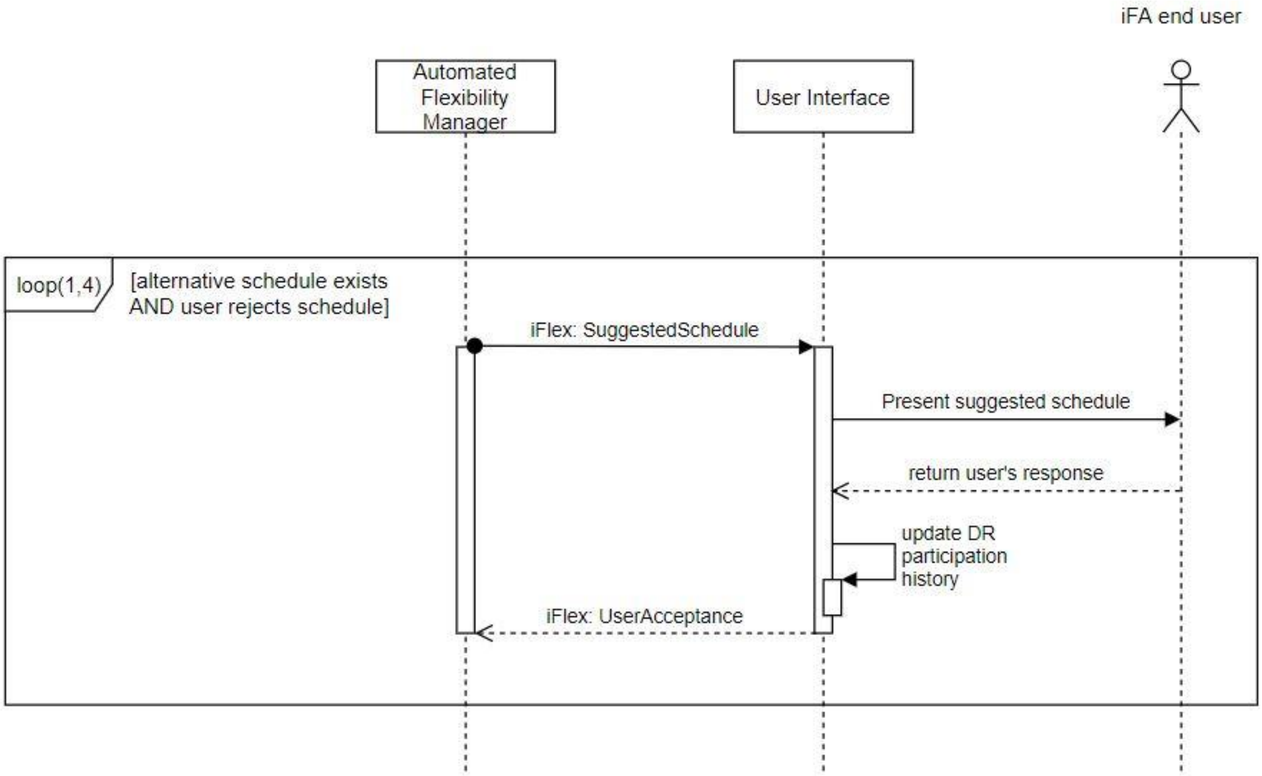

Figure 21: Sequence diagram of SUC-11 - Grant acceptance to schedules, Scenario: Manual operation

Table 4: SUC-11 - Grant acceptance to schedules, Scenario: Manual operation

SUC-11	Grant acceptance to schedules
Related PUC	PUC-9 - Optimise schedule considering prices and/or incentives PUC-10 - Increase self-balancing through forecasting and automation
Related requirements	FN-UI-08 - Provision of acceptance for the schedules of dispatchable assets FN-UI-22 - Presentation of DR event history
Scenario	Manual operation
Brief description	User acceptance procedure regarding iFA-suggested schedules for flexible assets.
Assumptions	1. The iFA is parameterised and fully operational. 2. The user wants to grant acceptance himself/herself to each iFA-suggested schedule (manual operation).
Preconditions	1. An event (e.g. participation in a DR event) took place which triggered the calculation of optimal schedules for flexible assets by the iFA. 2. The AFM component has come up with the optimal schedule for flexible assets.
Postconditions	1. In case of user rejection, AFM is notified and DR event participation is cancelled. 2. In case of user acceptance, AFM is notified
Relevant pilots	Greece, Slovenia

5.2.4 SUC-12: Present reports

The end users can access through their iFAs flexibility reports in order to have a clear view on their participation in explicit DR events.

As regards the part of this procedure which is related to the UI component, the A&M Interface sends a flexibility report to the UI. Then, the report is stored in the UI and a notification is sent to the iFA end user. The steps are presented in Figure 22.

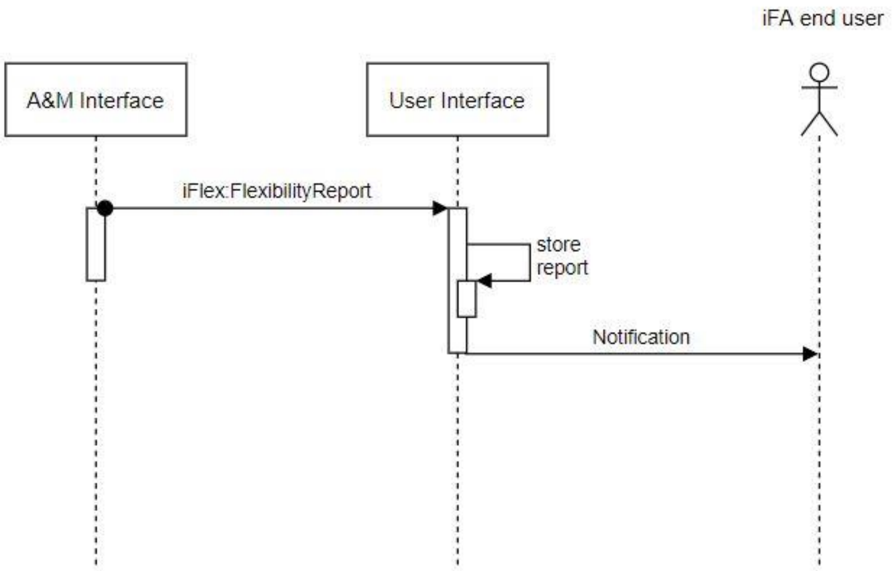

Figure 22: Sequence diagram of SUC-12 - Present reports, Scenario: Receive new flexibility report

Table 5: SUC-12 - Present reports, Scenario: Receive new flexibility report

SUC-12	Present reports
Related PUC	PUC-4 - View reports for participation or engagement PUC-5 - View energy advice
Related requirements	FN-UI-13 - Flexibility reports
Scenario	Receive new flexibility report
Brief description	The UI receives a new flexibility report from the A&M Interface and presents it to the iFA end user.
Assumptions	1. The iFA is parameterised and fully operational. 2. The iFA end user is enrolled in an explicit DR program. 3. Flexibility reports are generated by the external DR system and sent to the A&M Interface of the iFA. 4. Following the completion of an explicit DR event in which the iFA end user has participated, a relevant flexibility report is sent.
Preconditions	The A&M Interface component has received a flexibility report from the external DR system.
Postconditions	The iFA end user can access the flexibility report via the UI of the iFA.
Relevant pilots	Finland, Greece, Slovenia

5.2.5 SUC-13: Define comfort levels

The iFA end users should be able to set various operation modes, in which time and operational limits of flexible assets are defined. Furthermore, users should be able to choose between scheduled and flexible operation modes, depending on their desired level of flexibility.

First, the iFA end user accesses either the flexible or the scheduled operation modes' page. Then, the user chooses a flexible asset and sets the preferred time and operational constraints. If this is convenient for the user, the UI supports the capability of grouping more flexible assets under a single operation mode. Upon completion of this procedure, the operation mode is stored in the UI component, so that it can be activated by the user when desired. Once the activation status of an operation mode changes, a relevant signal is communicated by the UI to the AFM component, so that the user preferences are considered while devising the schedules for flexible assets. Finally, all modifications concerning the activation status of operation modes should be stored in the UI. The procedure is presented in Figure 23.

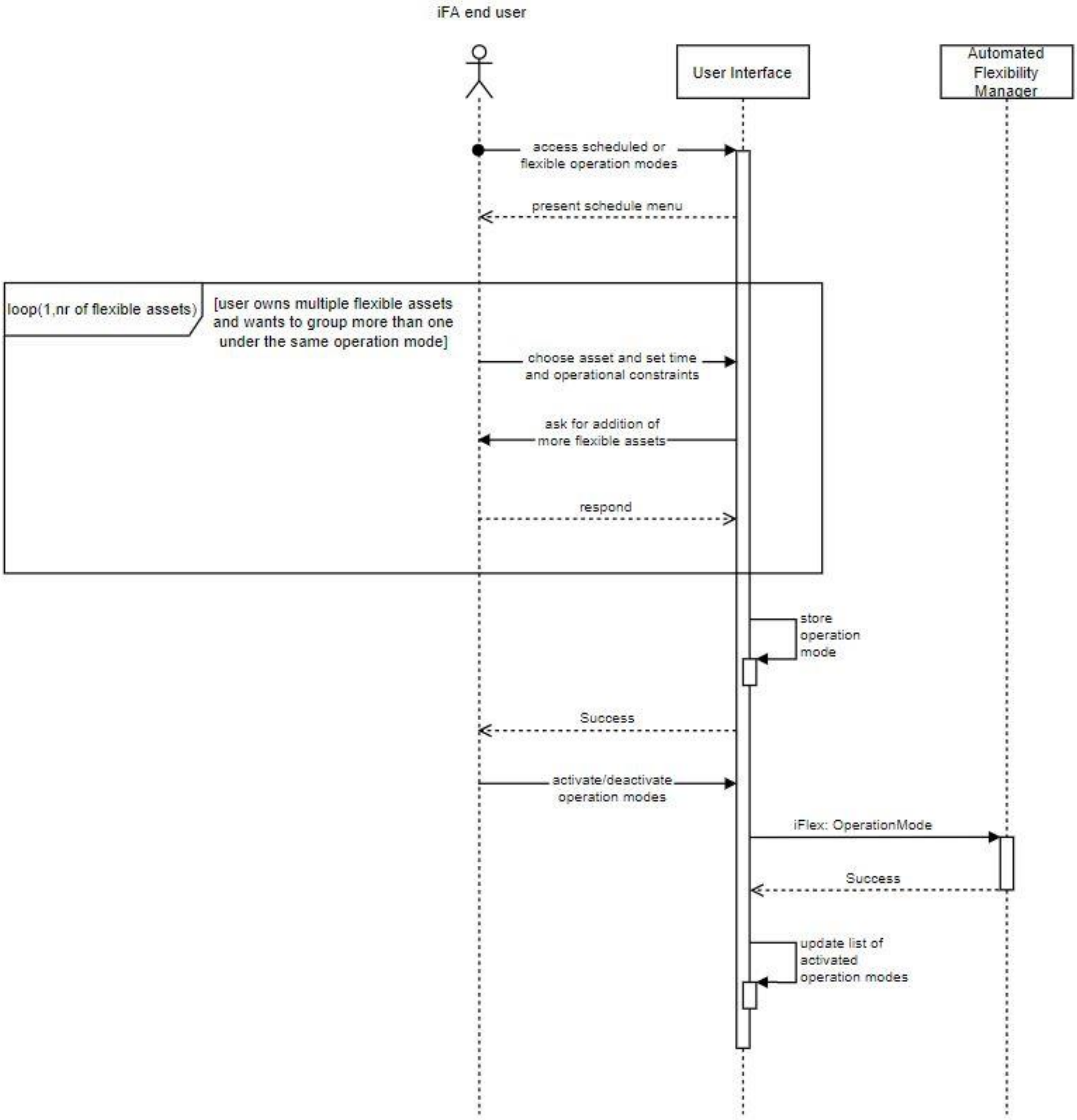

Figure 23: Sequence diagram of SUC-13 - Define comfort levels, Scenario: Set schedules of flexible assets

Table 6: SUC-13 - Define comfort levels, Scenario: Set schedules of flexible assets

SUC-13	Define comfort levels
Related PUC	PUC-1 – Manage my preferences
Related requirements	FN-UI-01 - Operation mode customisation FN-UI-02 - User-defined time and operational constraints FN-UI-05 - Automation level customisation
Scenario	Set schedules of flexible assets
Brief description	iFA end users can set flexible or scheduled operation modes for their flexible assets (automated operation) or deactivate them, thus opting for manual operation. Furthermore, grouping more than one assets under the same operation mode is possible, so that the user can define multiple preferences at once.
Assumptions	1. The iFA is parameterised and fully operational. 2. The iFA end user owns at least one flexible asset.
Preconditions	-
Postconditions	User preference on operation modes are stored in iFA. The AFM component takes into account the activated operation modes while devising the optimal schedules of flexible assets.
Relevant pilots	Greece, Slovenia

5.2.6 SUC-14: Provide feedback on thermal comfort

The end-users should be able to provide feedback on their thermal comfort in situations when space heating of a building is utilised as a source for flexibility. In phase one, this use case is relevant for the Finnish pilot. The thermal comfort feedback is utilised by the iFLEX support team and the Facility Manager to monitor flexibility management events.

Figure 24 displays a sequence diagram about the thermal comfort SUC. The end-users (residents) are provided with means to notify the iFA about their thermal comfort. The thermal comfort feedback is stored within the End-user interface (Resident interface). The End-user interface provides interfaces for the iFLEX support team and the Facility manager to access the data.

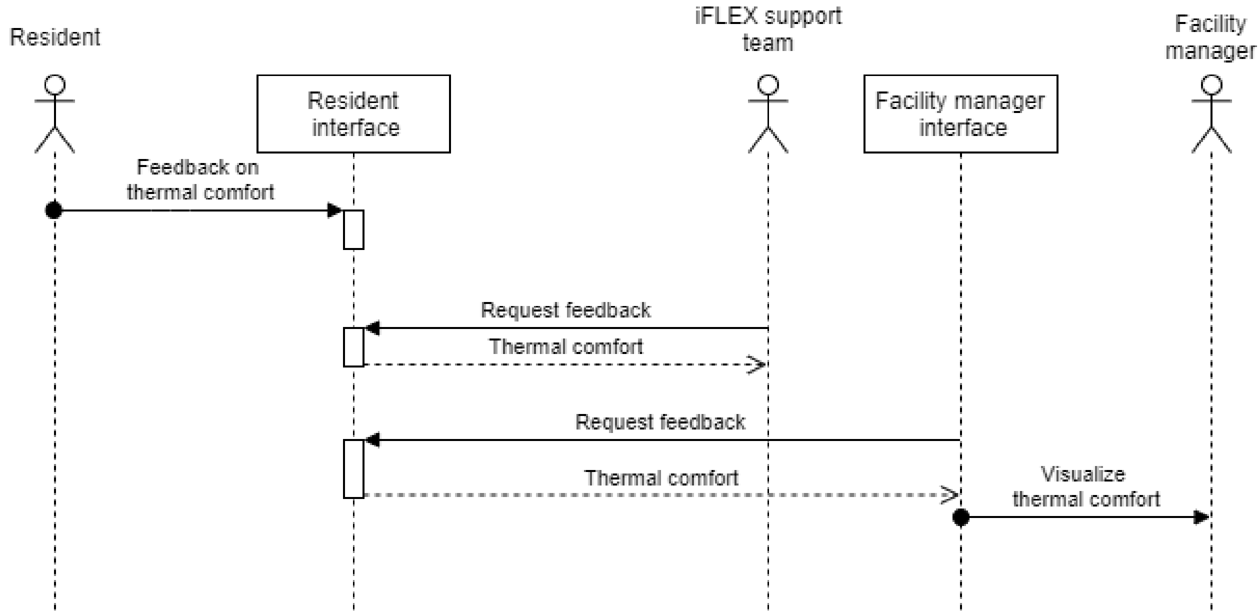

Figure 24: Sequence diagram of SUC-14 - Provide feedback on thermal comfort

Table 7: SUC-14 - Provide feedback on thermal comfort

SUC-14	Provide feedback on thermal comfort
Related PUC	PUC-1 – Manage my preferences
Related requirements	FN-UI-03 – End-user feedback
Brief description	iFA end users can provide feedback on their thermal comfort via the End-user interface. Thermal comfort is represented with seven scale thermal comfort index represented as smileys to the end-user. The thermal comfort information is provided to the iFLEX support team and the facility manager to monitor the impact of flexibility management events to the end-user. This data provides additional information to the sensor measurement data available from the pilot sites.
Assumptions	Space heating of a building is utilised as a source for flexibility.
Preconditions	1. The iFA is parameterised and fully operational. 2. The end user has access to iFA interface.
Postconditions	End-used feedback on thermal comfort is available for further analysis.
Relevant pilots	Finland

5.3 Information View

This section documents a static view of the data related to the UI component. Table 8 summarises the information objects which are relevant to the UI, as these were described in [9].

Table 8: Information objects relevant to the UI component [9]

Data item	Description	Data type
Energy consumption and production data	Data about energy consumption and production of flexible asset (historical and current) to be visualised to end-user	Measurement data
Performance metrics	The performance metrics that are visualised to the end-user. The visualisation is related to the end-user's goals visualisation and is guided according to the user preferences.	Measurement data
History and current thermal comfort data	Data about the historical and current thermal comfort (collected by the EMS) provided to the end-user.	Measurement data (report)
Flexibility signals	A signal to inform iFA about a flexibility event. Flexibility signal can be either an explicit DR event (i.e., activation of flexibility potential) or an implicit DR event (i.e., dynamic price information).	Flexibility data
iFLEX (flexibility) suggestions	A proposal for the end-user to modify a schedule or setpoint of a flexible asset. iFLEX suggestions need to be approved (User acceptance signal) before they are taken into account by the iFLEX Assistant.	Flexibility data
Flexibility report	Report on flexibility event results (e.g. rewards, cost-reductions, etc.).	Flexibility data
Flexibility services	A list of available services for end-users.	Flexibility data
Flexible asset state	Data about the current state of the flexible asset.	State data
Energy cost estimates	Estimates (not official) of end-user energy costs based on consumption and energy price data (possibly for different energy vectors).	Market data
District heating (DH) tariffs	The current district heating price defined by district heating operator.	Market data
Electricity network tariffs	The current network price defined by network operator.	Market data

Electricity retail tariffs	The current electricity price defined by electricity provider.	Market data
Static price data	Information on end-user energy and network fees. This information is used to estimate the energy costs.	Market data
Energy tariffs	Includes all the energy related tariffs, such as dynamic electricity price, network price and district heating price.	Market data
Feedback data	End-users' feedback about the residential comfort.	Feedback data
History of energy consumption and CO2 emission data	Data about the historical consumption and CO_2 emissions (collected by the EMS) provided to the end-user.	Report
Alert	An alert that is sent to end-user according to certain (predefined) events e.g., the power consumption exceeds a certain predefined threshold.	Alert
Flexibility signal response	An acknowledgement of the flexibility signal.	Acknowledgement
Preferences and configurations	A set of operational constraints and configuration of communication with iFA defined by the end-users.	End-user data Configuration data
Service registration request	End-user's expression about his/her interest to register to a service.	End-user data
Register (consent)	A message from end-user to register to the iFLEX Assistant. Registration process includes the informed consent of the end user that is required for collecting, storing and processing data under GRPR.	End-user data (registration/ informed consent)
User acceptance	End-user's acceptance on iFLEX suggestions.	End-user data

The information objects which are relevant to the User Interface component are presented in the following figures (i.e. Figure 25 and Figure 26). In these figures, signals related to user preferences, optimisation policy, operation modes, user acceptance and iFLEX suggestions are disaggregated in detail via class diagrams. The presented classes are part of the iFLEX data model. It is noted that other information objects related to the UI module, such as flexibility services, flexibility reports, energy data and energy tariffs, have already been detailed in D4.4 [11].

More specifically:

- Figure 25 presents the main attributes of User Preferences entity, relating it to the concepts of optimisation policy (OptimisationPolicyType), DR preferences (DRPreferencesType) and operation constraints (OperationModeType, AssetLimit) of energy assets. The iFA calculates the schedules of flexible assets, as well as manages DR event communications and makes decisions (in an automated manner) based on the above concepts.
- Figure 26 presents the class diagrams of UserAcceptance and iFlexSuggestion. In Phase 1, the emphasis is put on the iFA-suggested schedules for flexible assets and the user's response to them. As regards acceptance of DR events, more details can be found in the class diagrams described in D4.4 [11].

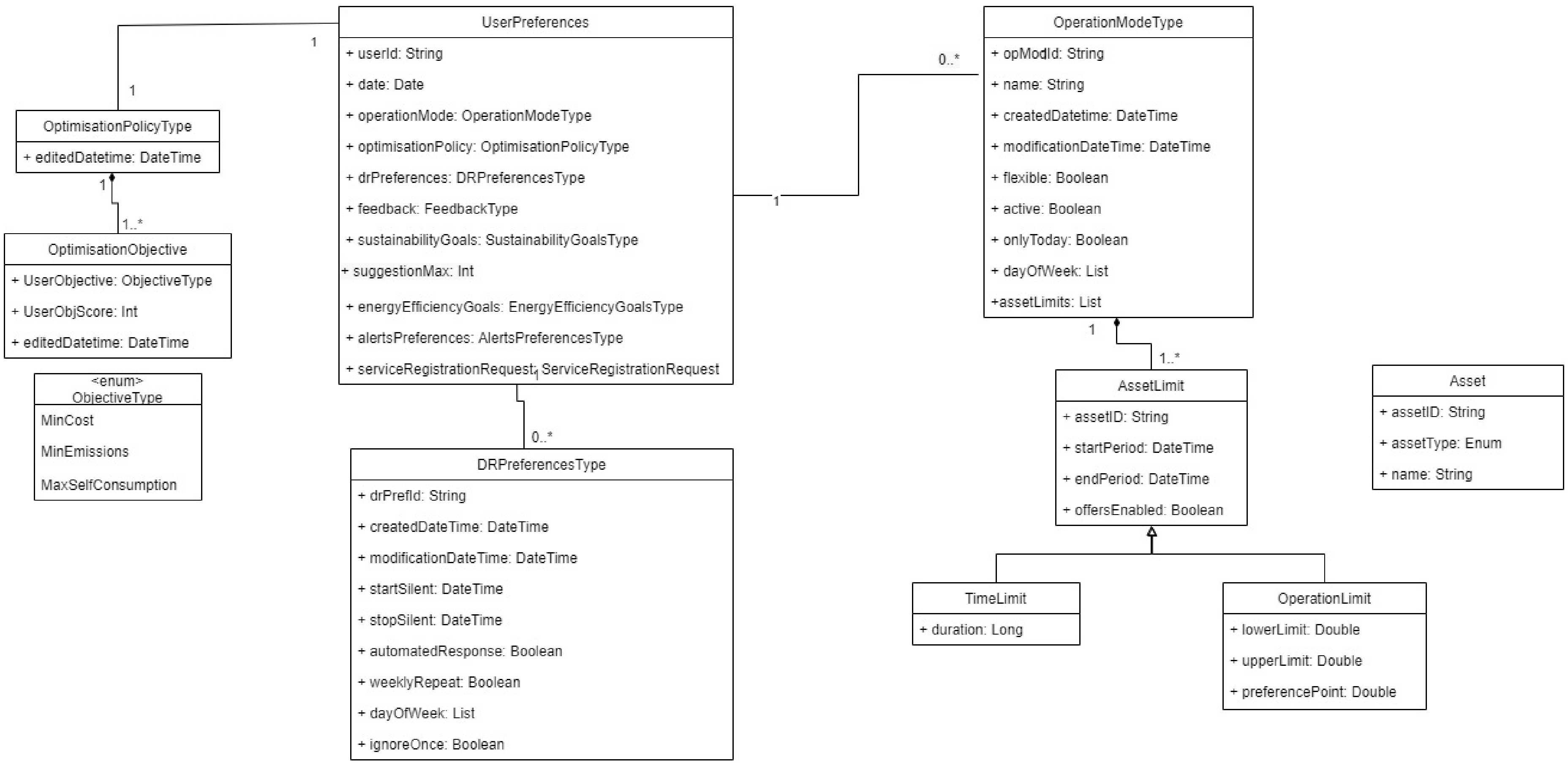

Figure 25: Class diagram of User Preferences

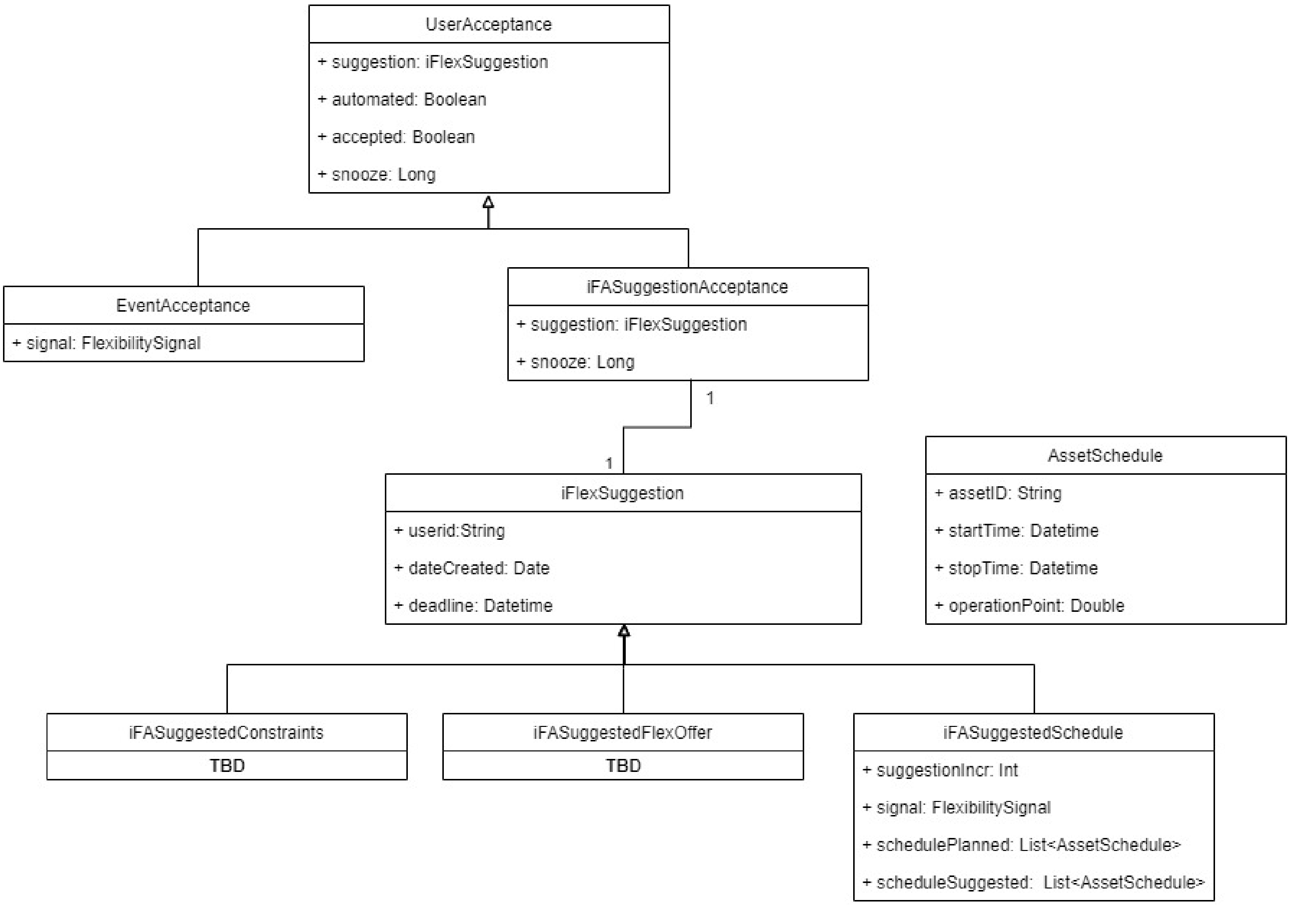

Figure 26: Class diagram of iFLEX Suggestions

5.4 User Interface Design

This section presents the up-to-date progress regarding the User Interface Design of the iFLEX Assistant. First, the solution for individual end users is exhibited. Then, the work on the User Interface of the building community is shown.

5.4.1 Individual end users (Greece, Slovenia)

5.4.1.1 Introduction

This version of the iFA's User Interface is intended for individual end users. Hence, it will be deployed in the Greek and Slovenian pilots of the project.

One of the main goals during the design of the application was to provide a friendly and simple user experience, so that the users would perceive the application as their personal assistants. The wording content of the application was carefully picked – utilising first person language so as to create a sense of dialogue between the user and the application.

Furthermore, for certain functionalities of the Assistant, such as optimisation policy and operation mode, there are different alternative approaches that are considered and will be assessed through A/B testing [13] with pilot users. For economy of space, the different alternatives are not presented in this document.

5.4.1.2 App Initiation

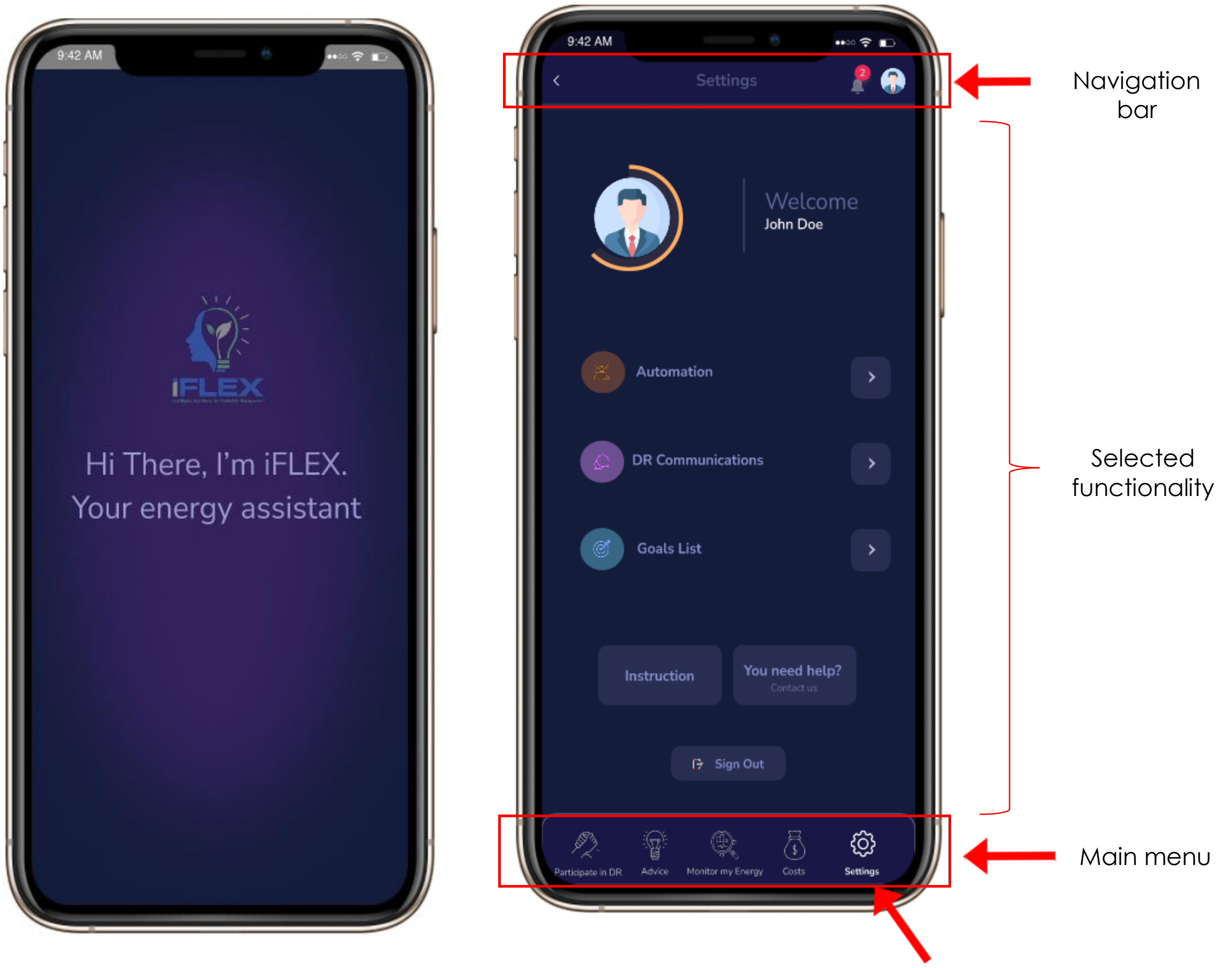

Figure 27: Welcoming and landing screen

At this stage of the design of mock-ups, the landing screen is the "settings" screen. In the main menu, which can be found in the lowest part of every screen, the options "participate in DR", "Advice", "Monitor my Energy", "Costs" and "Settings" are available. In the navigation bar at the top of the screen, there is a back button, the notifications and the user profile. In the lower part of the screen, actions such as "Sign Out" and the Help Centre of the application can be found. This page is shown in the above figure. While navigating through the mobile app, based on the user's choice among the options in the main menu or navigation bar, the selected functionality is displayed.

5.4.1.3 Automation

In the settings menu, options such as "Automation Settings", "DR communications" and "Goals List" can be accessed. When selecting on "automation settings", the application leads users to a menu with the following options: "My Objectives", "My Schedule", "My Flexibility". Selecting on the first option, users are directed to a screen where they can select their optimisation policy. This screen was designed with the thought that users will have the possibility to select many policies at the same time and prioritize them based on what is more important to them. This way, the iFLEX Assistant will make decisions while trying to accomplish the user's objectives. The relevant screens can be seen in Figure 28.

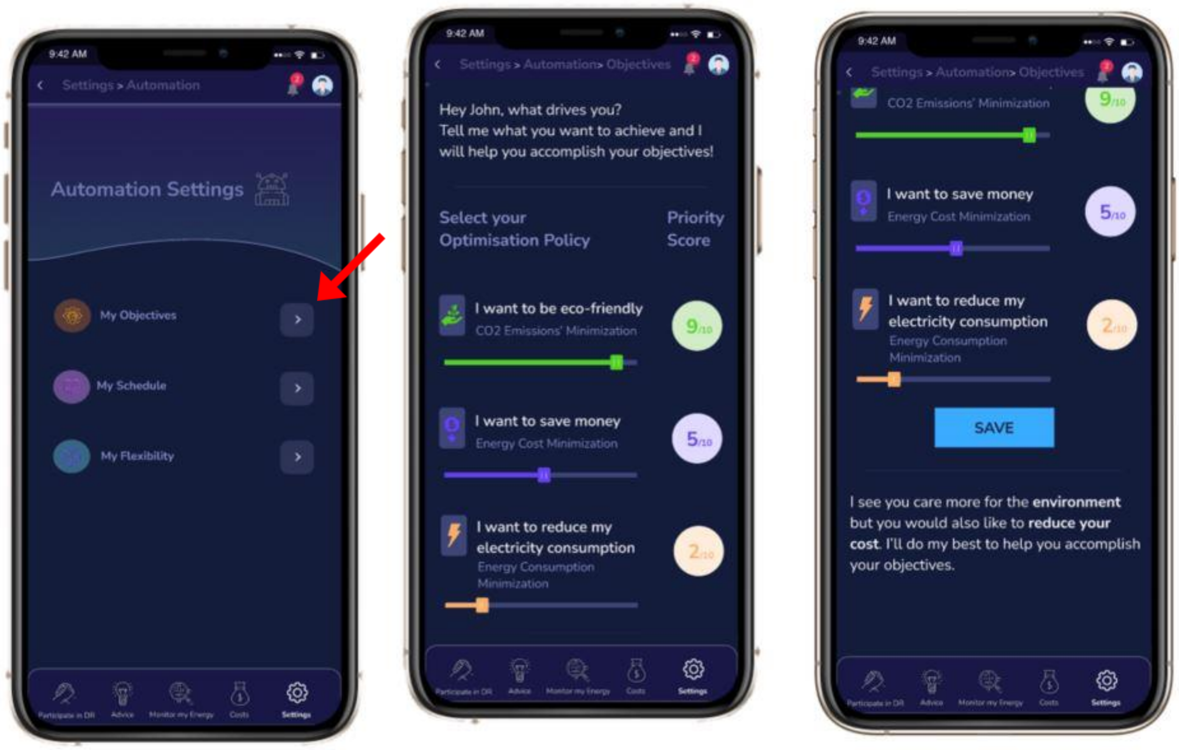

Figure 28: Selection of optimisation policy

Back to automation settings, when selecting on the second option called “My Schedule”, users can find all the schedules they have set, as shown in Figure 29. At the top of the screen there is the button “Add new schedule”. Below this button, users can find all the saved schedules. The users set the desired schedule per asset and are equipped with the ability to group the guidelines for more than one assets under an operation mode. This way, they can control multiple assets defining a single operation mode – and save the mode in case they want to activate it again. For each saved operation mode, information such as the days of the week that this mode is activated, the assets, the name of the operation, etc. can be found. The users are also able to edit each saved operation mode, delete it, activate it or deactivate it.

In case users would like to add a new operation mode, they will have to select on the button “Add New Schedule” which is going to lead them to a form. Users have to give a title for the new operation and define the days for the specific operation. Next, the users must select an asset from a dropdown list and give specific details about the desired operation of the asset and the specific hours. When all the fields are filled, users select “set schedule” and then a pop-up window appears asking them if they want to add a new asset within the same scheduled operation mode. If the users select “yes”, then the same form appears with one more “tab” added for the new asset. The users must again fill in the fields related to this asset. The first two fields are the same for every asset within the same scheduled operation mode. Again, when all the fields are filled, the users select “set schedule” and the pop up window appears again. If the users don’t want to add another asset within the same scheduled operation mode, they select “no” and the operation mode is saved and activated.

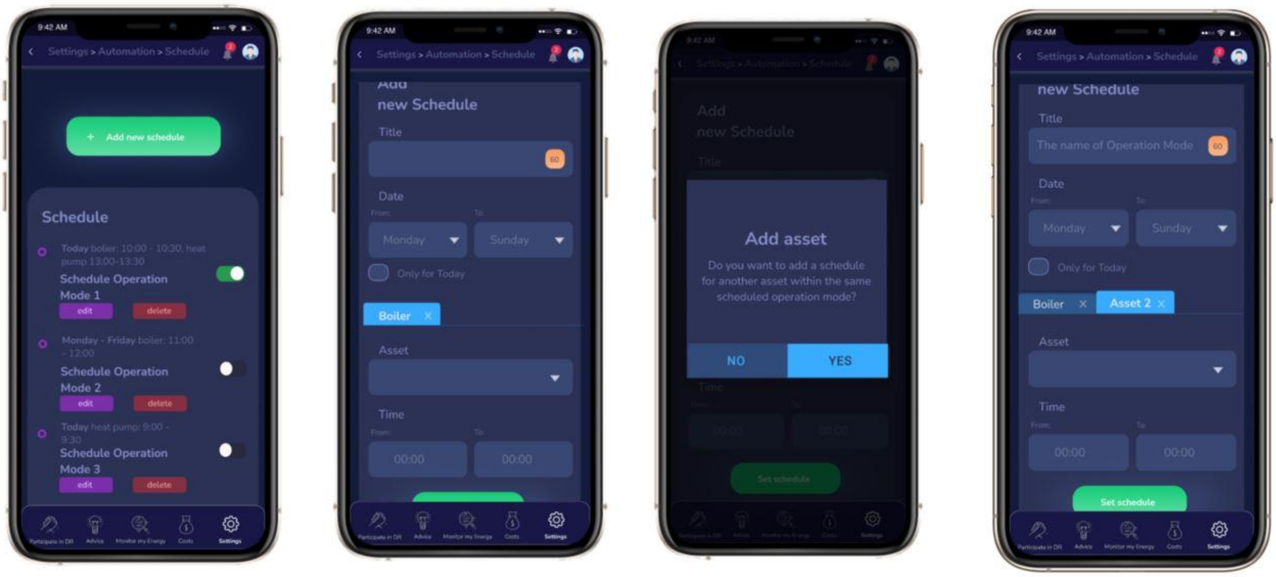

Figure 29: Scheduled operation modes

Back to automation settings, when selecting on the third option called “my flexibility”, users can find all the flexible operation modes they have set. The logic is exactly the same as before with the only difference being that when users want to add a new flexible mode, they do not need to fill in the exact hours for the asset, but instead they fill in an available time slot within which, the asset will work for a specific duration set by the users. Depending on the asset’s characteristics, through a flexible operation mode it might also be possible to define a range of acceptable operation instead of an exact operation point. For example, this could be applied to the temperature limits of a heat pump. The difference from the scheduled operation modes is presented in Figure 30. There is also a check box asking the users if they agree to the iFA sending flexibility offers to the Aggregator, based on their calculated flexibility.

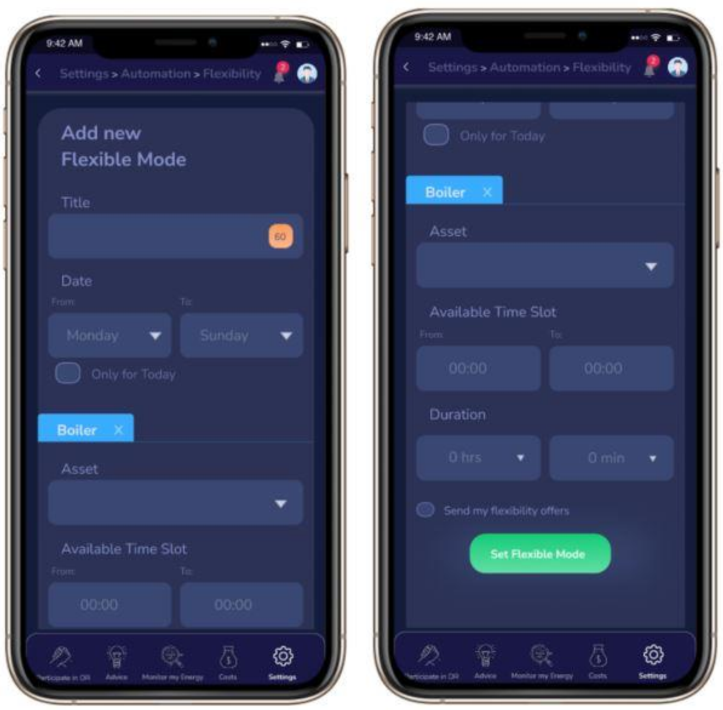

Figure 30: Setting a flexible operation mode

In case of a conflict between operation modes, the users are informed and asked to choose between two options: Either edit the operation they just created or continue anyway saving and activating the new mode and deactivating the conflicting mode, as shown in Figure 31.

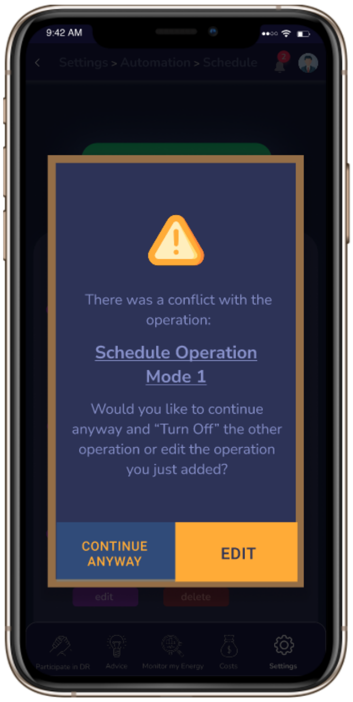

Figure 31: Resolving conflicts between operation modes

Heading back to the general settings menu, when selecting on the second option called "DR communications", user's saved silent periods are displayed. The silent period means that the user will not receive any notifications related to DR during this period. On top of that, users can decide on the level of autonomy that they will give to iFA through the silent periods. More details can be seen in Figure 32.

Figure 32: Configuration of DR communications

At the top of the displayed screen there is a calendar showing the current date. The application informs the users about the silent periods that have been added for the current day and allows them to easily remove a specific silent period by selecting the “x” found next to the time period. Below, there is a list with the saved silent periods and some edit actions. If users want to add a new silent period, they have to fill in two fields; one for the days and the other for the hours that the silent period will be activated. Then, they have to choose whether they want to execute these commands on a weekly basis or only once. Users can also choose whether to allow the iFA to respond to various notifications for events that may be sent during that period or not. If the user allows iFA to respond, then iFLEX will decide whether to accept or reject the event. When all the fields are filled, the user selects “set silent period” and the silent period is saved and activated.

5.4.1.4 DR Participation

In the main menu, which is found at the lowest part of the screen, when selecting on the first option which is called “participate in DR”, users are directed to the screen shown in Figure 33, where they can check their DR Participation History. Users can see not only the DR events in which they had participated in the past, but also those which they had rejected. At the top of this screen, users can see the total points earned through participation in DR events. Here, an approach based on a reward mechanism is presented, so that users can gain a reward once they have reached a specific number of points. Based on this, there is a bar informing the users of the remaining points to be earned until the next reward.

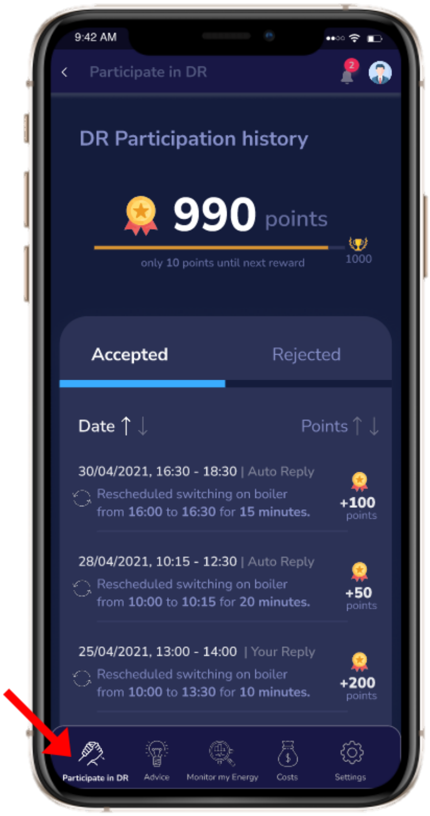

Figure 33: DR participation history

5.4.1.5 Monitor my energy

In the main menu found at the lowest part of the screen, when selecting on the third option which is called “Monitor my Energy”, users are directed to the screen shown in Figure 34. In this screen, users are able to access information on their energy data - and they can also set the exact period of time for which they would like to retrieve their data. Additionally, one has the option to select the desired time resolution, for example, data per hour, per week etc. Below, there are cards with various metrics for the user’s selected time period. There is also a graph with the lines in different colours and the legend at the bottom, which describes each colour’s functionality. On the right of the asset’s name there is an “eye”. By selecting on it, the user can hide data from the graph, so that they can focus on the consumption of specific assets for the desired time period.

Figure 34: "Monitor my energy" screen

5.4.1.6 Notifications

In Figure 35, various notifications are displayed. For example, when receiving a pop-up notification about an explicit DR event, this means that the users have to change their consumption accordingly in order to participate in that DR event. The users are notified of an upcoming DR event (when not in silent period) and are prompted to accept or reject it. After checking the date and time of the event, the users decide whether or not to participate in it.

If a user accepts a previous notification about participating in an explicit DR event, the iFLEX Assistant proposes after some time a rescheduling of a flexible asset, so that the user can participate in the upcoming DR event. In case the user rejects the suggested action, the iFLEX Assistant is trying to find another suggestion. Upon reaching the maximum number of rejections, the user is notified that participation in the DR event is cancelled, as iFLEX failed to find an acceptable solution.

By clicking on the “bell” at the menu found at the top of the screen, the user can find the “notification screen” with all the received notifications. Notifications about DR events to which the user has not responded yet, suggestions for rescheduling an asset, alerts etc. If a user "closes" a notification without responding, the notification is saved in the "notifications screen".

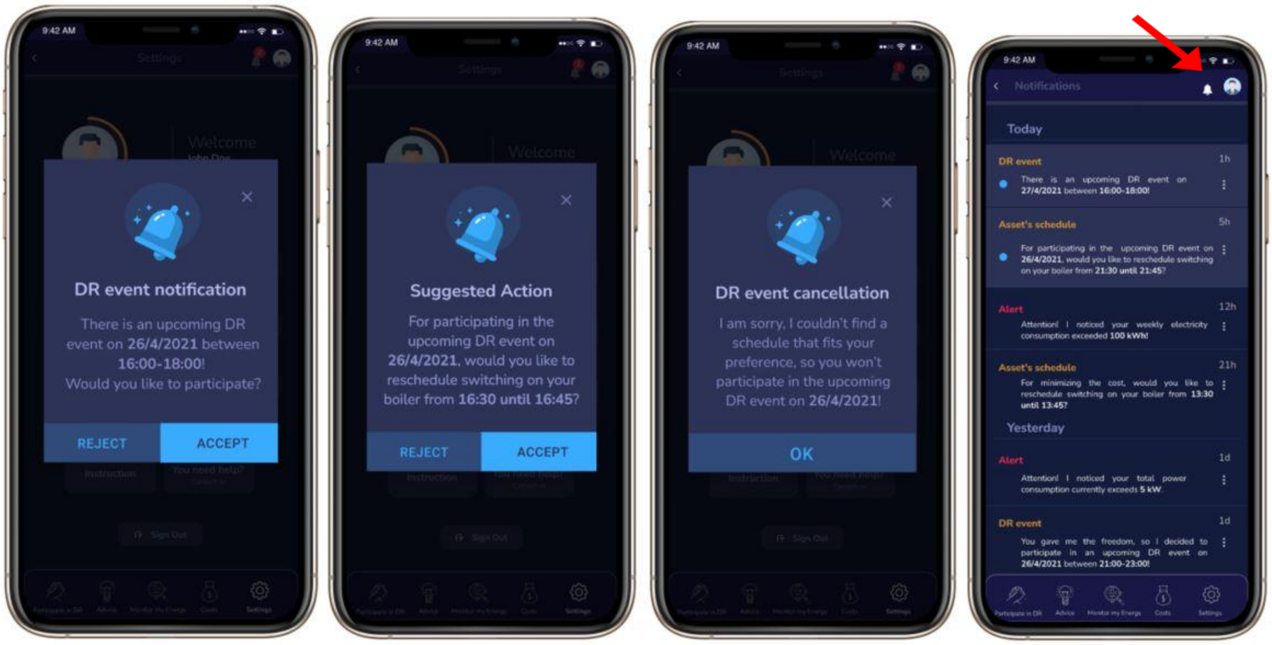

Figure 35: Screens related to notifications

It is noted that certain functionalities of the Assistant, such as energy advice, alerts, and cost monitoring will be developed in the next iterations of the iFLEX project. Hence, they are out-of-scope for the UI design of Phase 1.

5.4.2 Building community (Finland)

The 1st phase has two views based on whether a user has registered into the system or not.

- All residents of the building can view
  - building level electricity consumption
  - district heating consumption
  - CO_2 footprint.
- Registered users have (in addition to building level data) access to their own apartment data, including:
  - Thermal comfort visualisation (temperature and humidity)

5.4.2.1 Feedback system

All residents can give general building-level feedback, whilst registered users can give feedback about conditions in their own apartments. The following options are available:

- Thermal comfort (scale with 7 options: cold, cool, slightly cool, comfortable, slightly warm, warm, hot)
- Free text feedback

Figure 36: Thermal comfort scale

Data is fetched from measurement server REST-API interface in oBIX[11] format. XML response is converted to JSON at backend proxy.

[11] http://www.obix.org/

5.4.2.2 Building level data

Using energy price information provided by the user, electricity view sums up electricity consumption (in kWh) and actual charge (in monetary terms) for three different periods: last 24 hours, last 7 days and last month. A more detailed line chart is also available, where user can select time range from 1 to 7 days and a 30-day history as a separate chart.

Figure 37: Building level energy consumption

5.4.2.3 Registered user

Registered users have access to thermal comfort visualisation data regarding their own apartments. Such data contain temperature and humidity for three different periods: last 24 hours, last 7 days and last month. A more detailed line chart is also available, where user can select time range from 1 to 7 days and a 30-day history as a separate chart.

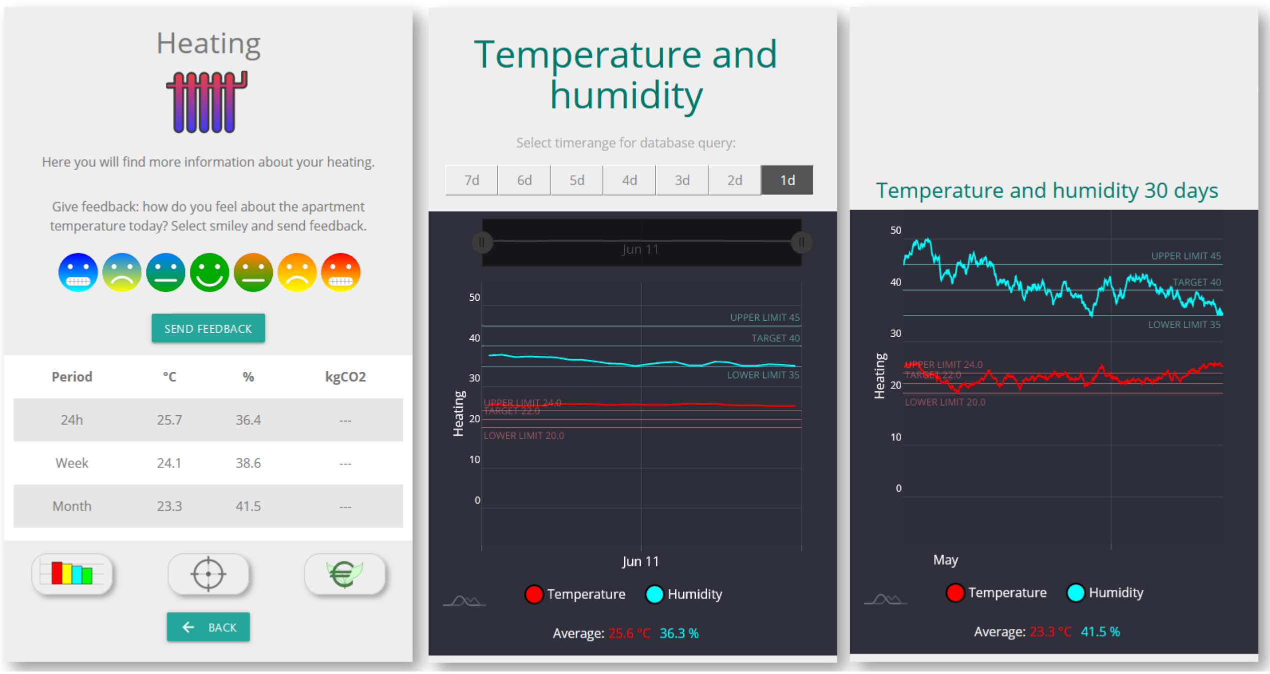

Figure 38: Registered residents' thermal comfort

6 Conclusions

The objective of this report is to guide the development process of the User Interface components of the iFA and to facilitate quick integration between different existing solutions and component prototypes. Towards the 1st goal, a detailed list of requirements concerning the User Interface is documented with the focus lying primarily on Phase 1. With regards to the latter goal, existing solutions and up-to-date progress on the User Interface components is documented as a base.

An iterative, user-centred design approach was chosen for the iFLEX project with the goal to simplify the participation of small-scale consumers and prosumers in flexibility services while ensuring a good user experience. Towards this, the concept of co-creation with end users was deemed critical by the project, so that the iFLEX solution is tailored to the actual needs and wills of the users. This report has also documented information on existing solutions related to user interfaces. First, the existing solution for the Finnish building community is presented, which will be extended within the context of the iFLEX project. Then, HERON's REMAP solution is analyse, as a reference for the implementation of the UI component of the Greek pilot.

On the basis of the activities of T2.2, a list of more granular requirements concerning the User Interface component - prioritised from the viewpoint of the different pilot sites - which was considered for the design of the prototype of the 1st phase, is documented in the report.

Design specifications concerning the UI component of the iFA are documented based on the Viewpoints and Perspectives framework and ISO/IEC/IEEE 42010:2011 "Systems and software engineering—Architecture description". More specifically, three views of the system architecture are described:

- Context view, presenting the interactions of the UI component with its environment at a high level;
- Functional view, focusing on the component's responsibilities and primary interactions with the iFA end users and other components of the Assistant. To be more precise, the described features of the UI component are related to:
    - accessing energy data;
    - customising and activating operation modes;
    - defining the optimisation policy of iFA;
    - granting acceptance to iFA-suggested schedules;
    - accessing flexibility reports via the iFA;
    - providing the iFA with feedback on thermal comfort; and
- Information view, detailing a static view of information objects relevant to the UI component, with the aim to serve as common ground for data flows exchanged between components developed by various project partners. The entities, which are detailed in this deliverable, concern iFLEX suggestions and user acceptance, as well as user preferences. The latter is further elaborated via classes relevant to optimisation policy, DR preferences, and operation modes.

As regards the UI design, an initial set of mock-ups of the user interfaces of the iFA is documented in this deliverable, including solutions for both individual end users and building communities.

Upon validating the design after this 1st iteration, functionalities relevant to the User Interfaces, refinement and/or additions will be added documented in subsequent iterations, namely deliverables D3.5 and D3.6.

7 List of figures and tables

7.1 Figures

7.2 Tables

8 References

[1] iFLEX Project, "D2.1 - Use cases and requirements," 2021.

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[6] ISO/IEC/IEEE, "ISO/IEC/IEEE 42010:2011, Systems and software engineering — Architecture description".

[7] iFLEX project, "D2.2 - User engagement and co-creation framework & plan," 2021.

[8] Making City project, [Online]. Available: https://makingcity.eu/the-project/. [Accessed 16th June 2021].

[9] iFLEX Project, "D2.3 - Initial common architecture of iFLEX Framework," 2021.

[10] iFLEX project, "D7.1 - Initial Pilot Specifications," 2021.

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[12] K. Fakhroutdinov, "UML Sequence Diagrams," [Online]. Available: https://www.uml-diagrams.org/sequence-diagrams.html. [Accessed 4th June 2021].

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9 Appendix / Annex

9.1 Requirements documentation

Story ID	*Title*	*Story narration*	*Source*	*Related requirements*	*Author*	*Developer*	*Priority*	*Implementation*		
								FIN pilot	**GR pilot**	**SL pilot**
FN-UI-01	Operation mode customisation	As an end user I want to be able to select among predefined operation modes and customise them according to my preferences, so that various operational choices are collectively determined on the basis of the operation mode.	PUC-1	FN-UI-02, FN-UI-05	ICOM	ICOM	High	TBD	1st Phase	TBD
FN-UI-02	User-defined time and operational constraints	As an end user I want the system to comply with my preferences regarding time and operation of devices and assets, so that the automated operation doesn't hinder my comfort.	PUC-1	FN-UI-01, FN-UI-05	ICOM	ICOM	High	TBD	1st Phase	TBD
FN-UI-03	End-user feedback	As an end user I want to be able to provide the system with feedback on its operation, so that potential divergences from my wishes can be reduced/eliminated.	PUC-1		ICOM	TBD	Low	1st Phase	TBD	TBD

FN-UI-04	Optimisation policy selection	As an end user I want to be able to define the system's optimisation policy, so that it conforms with my motives (e.g. cost, energy efficiency, environmental).	PUC-1		ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-05	Automation level customisatio n	As an end user I want to be able to choose the level of automation of the iFLEX Assistant's operation, so that I can enable/disable the automated operation whenever I want.	PUC-1	FN-UI-01, FN-UI-02	ICOM	TBD	High	TBD	1st Phase	TBD
FN-UI-06	Diversity of means of interaction with the system	As an end user I want to select among various means of interaction with the system, so that I can choose the one I prefer for a specific purpose.	PUC-1		ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-07	Supported system interface languages	As an end user I want to be able to choose among various languages for the system interface, so that I can opt for my preferred one.	PUC-1		ICOM	TBD	High	TBD	TBD	TBD
FN-UI-08	Provision of consent for the schedules of dispatchable assets	As an end user I want to be equipped with the ability to accept/reject the system-proposed schedules of dispatchable assets, so that I make sure that they comply with my will.	PUC-9, PUC-10		ICOM	TBD	High	TBD	1st Phase	TBD

FN-UI-09	DR notification policy	As an end user I would like to set specific time periods in which DR notifications are not allowed, so that I am not disturbed within these time slots.	PUC-1	FN-UI-21	ICOM	TBD	Medium	TBD	1st Phase	1st Phase
FN-UI-10	Insights into sustainability metrics	As a household end user I would like to set sustainability goals and track - based on them - my sustainability performance, so that I can get deeper insights into them.	PUC-3	FN-UI-15	ICOM	TBD	Medium	1st Phase	TBD	TBD
FN-UI-11	Real-time energy data	As an end user I want to be equipped with the ability to inspect my energy data in real-time, so that I can have a clear view of the current status whenever I want.	PUC-7	FN-UI-12	ICOM	TBD	High	1st Phase	1st Phase	TBD
FN-UI-12	Past energy data	As an end user I want to be equipped with the ability to inspect my past energy data, so that I can have a long-term view of my consumption/production data.	PUC-7	FN-UI-11	ICOM	TBD	High	1st Phase	1st Phase	1st Phase
FN-UI-13	Flexibility reports	As an end user I want to receive flexibility reports, so that I can have a more clear view with respect to my participation in explicit DR actions.	PUC-4	FN-UI-22	ICOM	TBD	Medium	TBD	TBD	TBD

FN-UI-14	Insights into energy efficiency	As an end user I want to set energy efficiency goals and track - based on them - my performance, so that I can control better my energy consumption.	PUC-7	FN-UI-15	ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-15	Customised alerts	As an end user I want to subscribe to customised alerts (e.g. when household power consumption or daily/weekly electricity consumption exceeds a user-defined threshold or certain milestones regarding energy consumption-related goals are achieved/missed), so that I am assisted in achieving my energy efficiency-related goals.	PUC-1, PUC-7	FN-UI-10, FN-UI-14	ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-16	Energy advising service	As a household end user I would like to subscribe to an energy advising service, so that I can improve my energy performance via following the proposed advice.	PUC-1, PUC-5		ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-17	Inspection of energy tariffs	As an end user I want to see my energy tariffs whenever I wish, so that I can have a transparent view of - even time-variant - energy tariffs and the ability to adapt my energy consumption accordingly.	PUC-9, PUC-10		ICOM	TBD	Medium	TBD	TBD	TBD

FN-UI-18	Available flexibility services	As an end user I would like to be informed about the available flexibility services, so that I can choose the most appropriate for me.	PUC-6	FN-UI-19	ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-19	Declaration of interest in a new flexibility service	As an end user I would like to be able to declare to the relevant market actor my interest in a new flexibility service via my system, so that I can do that in an easy way.	PUC-6	FN-UI-18	ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-20	End-user authorisation of system-proposed flexibility offers	As an end user I want to be able to authorise iFA to send flexibility offers to the market, so that I can decide when that happens.	PUC-9		ICOM	TBD	Medium	TBD	TBD	TBD
FN-UI-21	DR event notification	As an end user I want to receive DR event information (implicit: notifications of a change in tariff price - or explicit: communicating the activation information), so that I can have a clear overview of the current DR actions.	PUC-1, PUC-8	FN-UI-09	ICOM	TBD	High	TBD	1st Phase	1st Phase
FN-UI-22	Presentation of DR event history	As an end user I would like to be able to access my DR event history, so that I can review the impact of my participation in DR events.	PUC-4	FN-UI-13	ICOM	TBD	Low	TBD	1st Phase	TBD

9.2 User Experience Interview

A questionnaire concerning the initial iFLEX mock-ups is presented in this Section, which will be distributed to all project partners, so that they can submit their feedback on User Experience. This feedback can be exploited by the design team with the aim to improve the under-development UI design and supported features.

Introduction

An introductory section on iFLEX project, the Assistant and the scope of this session.

Demonstration

Tasks requested by the user are documented in this section.

General Questions

This section documents the questions that will be asked to the user, upon completion of the test.

1. On a scale of 1 to 5, rate your experience using the mobile application.

   [1 2 3 4 5 Scale]

2. How difficult is reading characters on the screen?

   [1 2 3 4 5 Scale – From Very Easy to Very Difficult]

3. How difficult is the app to use?

   [1 2 3 4 5 Scale – From Very Easy to Very Difficult]

4. How is the navigation of the mobile application?

   [1 2 3 4 5 Scale – From Very Bad to Very Good]

5. After looking at the mock-ups, do you think you will be able to achieve your goals?

   [Yes/No]

6. If you do not think you will be able to achieve your goals, why not?

   [Free Text]

7. Are there any features that you think you need but are missing in the mobile application?

   [Yes/No]

8. If yes, please describe.

[Free Text]

9. Are the terms that are used throughout the system understandable?

[Yes/No]

10. Do you have any comments about the wording used in this application?

[Yes/ No]

11. If yes, please specify.

[Free Text]

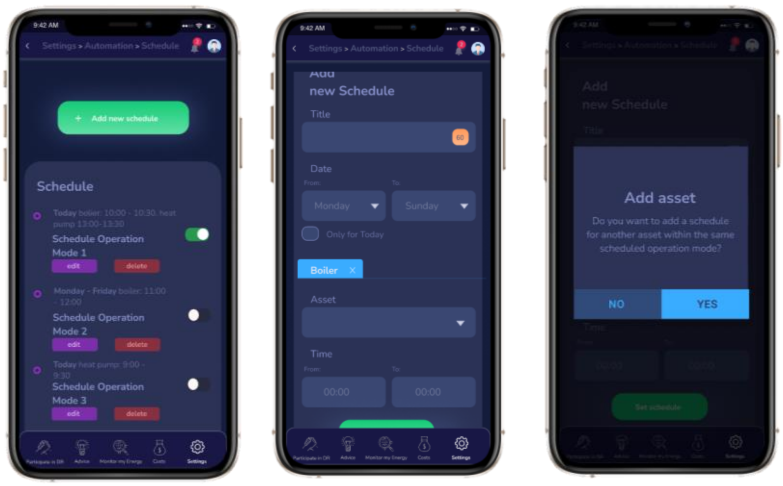
12. Did you find anything difficult or unnecessarily complicated when using this application?

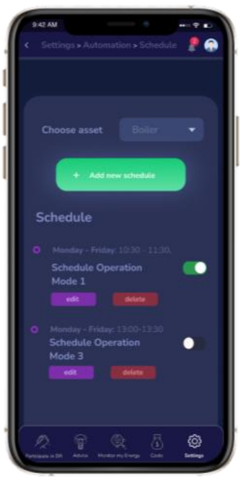
[Yes/No]

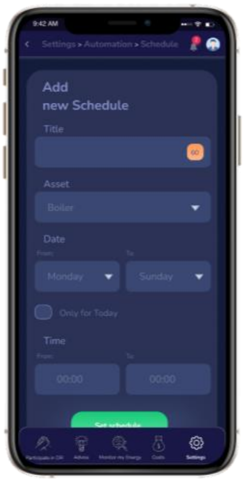
13. If so, why?

[Free Text]

Scheduling and Flexibility







14. Would you like to be able to group some assets in the same schedule operation mode (image 1, image 2 and image 3) or you prefer the separate programming for each asset (image 4 and image 5)?

[I prefer grouping/ I prefer separate programming]

15. Should you be equipped with the ability to add multiple timeslots for the same asset under the same operation mode or should these schedules be added via multiple operation modes (with maximum one timeslot per asset).

[Multiple timeslots for an asset under the same op. mode / Add via multiple op. modes]

Automation Settings

16. Did you find the automation settings unnecessarily complicated?

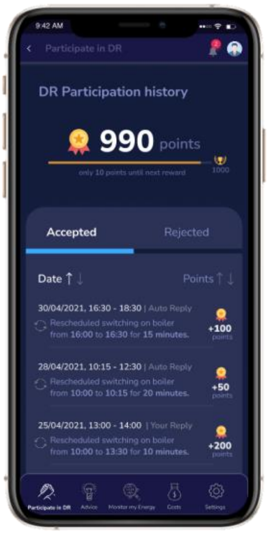
[Yes/No]

17. If yes, describe why.

[Free Text]

Home Screen/ Landing Page

18. Which screen would you prefer as your home (landing) page?



[a) Monitor my Energy b) Participate in DR c) Other]

19. If you previously answered other, please describe the functions you would like your landing page to have.

[Free Text]

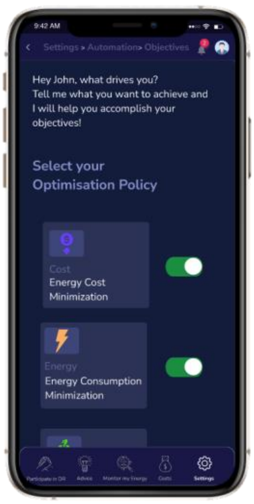
Optimisation Policy

20. Is optimisation policy selection important for you?

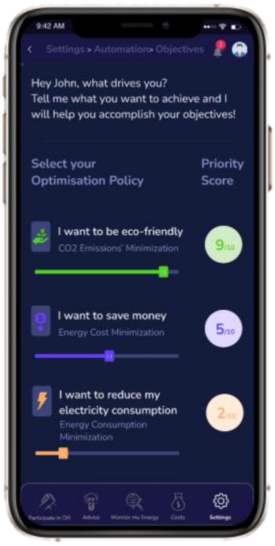
[Yes/No]

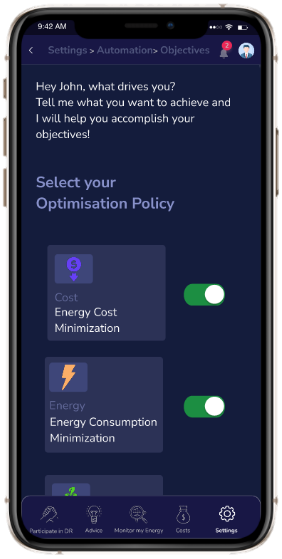
21. Is it useful for you to be able to select more than one options as drivers of the optimisation?

[Yes/No]

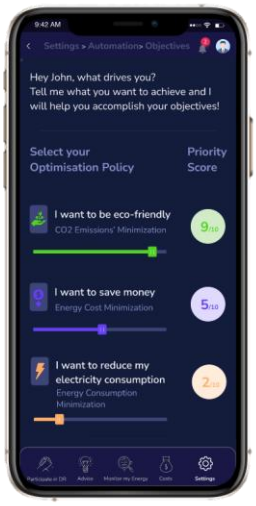


22. Which form would you prefer for selecting your iFLEX Assistant optimisation strategy?
[One choice among many]





23. Is optimisation policy prioritisation clear to you?



[Yes/No]

24. If not, please specify why.
[Free text]

Final Remarks

25. Are there any comments/suggestions that can help us improve the user interface for our users?
[Free text]