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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
CO ₂	Carbon dioxide
CSS	Cascading Style Sheets
DR	Demand Response
DTR	Digital Twin Repository
HLUC	High-Level Use Case
HTML	Hypertext Markup Language
iFA	iFLEX Assistant
JSON	JavaScript Object Notation
JWT	JSON Web Tokens
MVC	Model-View-Controller
oBIX	Open Building Information Exchange
PUC	Primary Use Case
RAI	Resource Abstraction Interface
REST	Representational State Transfer
RWD	Responsive Web Design
SO	System Operator
SQL	Structured Query Language
SUC	Secondary Use Case
SVG	Scalable Vector Graphics
TLS	Transport Layer Security
UC	Use Case
UI	User Interface

Executive summary

The iFLEX project 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. From the perspective of these actors, various Flexibility Procurers, such as System Operators (SOs) and Balance Responsible Parties (BRPs), can leverage flexibility from small-scale end users of the power system.

This deliverable falls within Task 3.3 of the project, which concerns the development of user interfaces that facilitate the interaction of end users with their iFLEX Assistants (iFAs). The objectives of this report are on one side to document the updated design and implementation achievements of the User Interface (UI) component of the iFA, whilst on the other to provide the guidelines for the final steps of the development process for supporting the last phase (i.e., Phase 3) of piloting, focusing especially on integration with other iFA components and leveraging the experience gained from the previous phases.

The design work was based on the high-level and primary use cases documented in D2.1, and the secondary use cases relevant to the UI component, which were initially reported in D3.4 and can be found also in the Appendix of this deliverable. Furthermore, the design work was also based on the set of more granular requirements concerning iFA's UI component – devised during the system analysis and documented in the Appendix of this report – as well as on the final architecture of the common iFLEX Framework described in D2.5. The co-creation activities with the iFA end users, which assist in the process of redesigning the application, as well as in adding new features to it, are also summarised in this deliverable. It is noted that this report presents the complete documentation for T3.3 on Natural User Interfaces, including also work from the previous deliverables of the task, namely D3.4 and D3.5, so that the reader can see the whole picture.

The envisioned functionalities of the UI module by the end of the project are reported by referring to the relevant requirements. Furthermore, the design of the UI solution is analysed via three architectural views:

- Context view, presenting the interactions of the component with its environment at a high level;
- Functional view, focusing on the functionalities of the various sub-components of the UI;
- Implementation view, documenting the technology stack for the instantiations of the UI component per pilot.

Finally, the most recent UI design of the applications for the three pilots of the project is presented.

This document will serve as a guide for the iFLEX consortium with respect to the UI component's development, integration, and piloting process in the final phase of the project, as well as for the general public as the primary documentation on the work done in the iFLEX project under T3.3 on Natural User Interfaces.

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 iFA 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 Task 3.3 of the project, which is responsible for developing user interfaces that will facilitate the interaction of end users with their iFAs.

1.1 Purpose, context and scope

Based on the agile approach of the iFLEX project, there are three deliverables on Natural User Interfaces corresponding to the three phases of the project’s implementation. The current document, D3.6, has two main objectives:

- To guide the development process of the iFA’s User Interface (UI) component in the final phase of the project via documenting its full set of requirements.
- To facilitate quick integration amongst the UI and other iFA components. Hence, the up-to-date development progress on the UI is documented as a base.

It is noted that this is the final deliverable of Task 3.3, as the initial and revised UI modules are reported respectively in D3.4 [1] and D3.5 [2] of the iFLEX project.

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 to the report. This chapter also provides a summary of changes compared to D3.4 and D3.5 in Section 1.3;
- Chapter 2 provides an overview of the UI component within the iFLEX context, focusing on the achievements of Phases 1 and 2, the planning of Phase 3, and the UI-related co-creation activities with end users;
- Chapter 3 presents the documentation of implementation aspects of the solution, considering different system architecture views (i.e., context, functional, implementation views) and the up-to-date UI design;
- Chapter 4 concludes the report with main outcomes.

1.3 Summary of changes compared to D3.4 and D3.5

This section summarises the changes in this deliverable compared to D3.4 and D3.5, namely the initial and revised documents on the Natural User Interfaces respectively.

As regards the logic, in D3.5 it was decided to report only the “delta” compared to D3.4 in each section. However, in this deliverable, namely D3.6, according to the iFLEX consortium’s agreement on the content of technical deliverables of the final phase, the complete documentation relevant to T3.3 – Natural User Interfaces

– is reported. Hence, work originally documented in D3.4 and D3.5 is also included here, so that the reader can see the whole picture on the task without the need to refer to the previous deliverables.

There are two exceptions in the above logic. First, the presentation of initial design considerations, such as solutions pre-existing to the project, which was reported in D3.4, is omitted as redundant. The reader can be informed about the actual user interfaces developed for the purpose of the iFLEX project and deployed in the three pilots by this document (D3.6). Secondly, the information view was decided by the iFLEX consortium to be reported in the WP2 deliverables. Thus, the most recent documentation on the information view for T3.3, along with the rest of the tasks, can be found in D2.5 – Final Architecture of iFLEX Framework [3].

Below, the updates per chapter of the document – compared to the previous one, namely D3.5 – are summarised:

- Chapter 1: The introduction has been updated to reflect the scope, context, and structure of this deliverable.
- Chapter 2: Sections on the end users and relation to requirements and iFLEX Framework architecture have been added, as originally reported in the initial document (D3.4). The rest of the sections (i.e., achievements of Phases 1 and 2 per pilot, focus of Phase 3 per pilot, and co-creation with end users) have been updated with the most recent information.
- Chapter 3: Functional and implementation views, as well as design of the UI solutions per pilot have been updated with the most recent information.
- Chapter 4: Conclusions have been updated according to the current status and planning for T3.3.
- Appendix: The section on requirements documentation has been updated based on the most recent status and planning per pilot. A section on the functionalities of the User Interface component has been added in the Appendix, as originally documented in the functional view for this component in the Implementation chapter of D3.4, so that the reader is provided with the whole picture.

2 Overview

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.

2.1 End Users

The potential end users of the system under development were identified during the design process, so that appropriate requirements could be elicited. The solutions related to T3.3 concern the iFA end users, who were 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 gaining profit through offering the aggregated flexibility of their establishment(s) to the flexibility market. The interaction of these users with their iFA is enabled via a User Interface tailored to their interests.

2.2 Relation to Requirements

The main interactions of the iFA with external systems and end users were analysed in the form of High-Level Use Cases (HLUCs) and Primary Use Cases (PUCs)¹ during the process of requirements' elicitation of T2.2. Furthermore, a set of Secondary Use Cases (SUCs), which was specific to the UI component, was elicited to describe in a more detailed way the interactions of the UI with the other iFA components and the end users. These SUCs were originally documented in D3.4 and can be also found in the Appendix of the current document (Section 7.2). As documented in D2.1 [4], all the identified HLUCs and PUCs of the project concern the UI component, whilst a set of User Stories is also documented for capturing the 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 – mostly focusing on the user's experience with the iFA – and are documented in the Appendix (Section 7.1) of this report.

2.3 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 building 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 1, where the focus of T3.3 activities and correspondingly of the UI component is highlighted.

¹ For information on use case terminology the reader should refer to D2.1 [5].

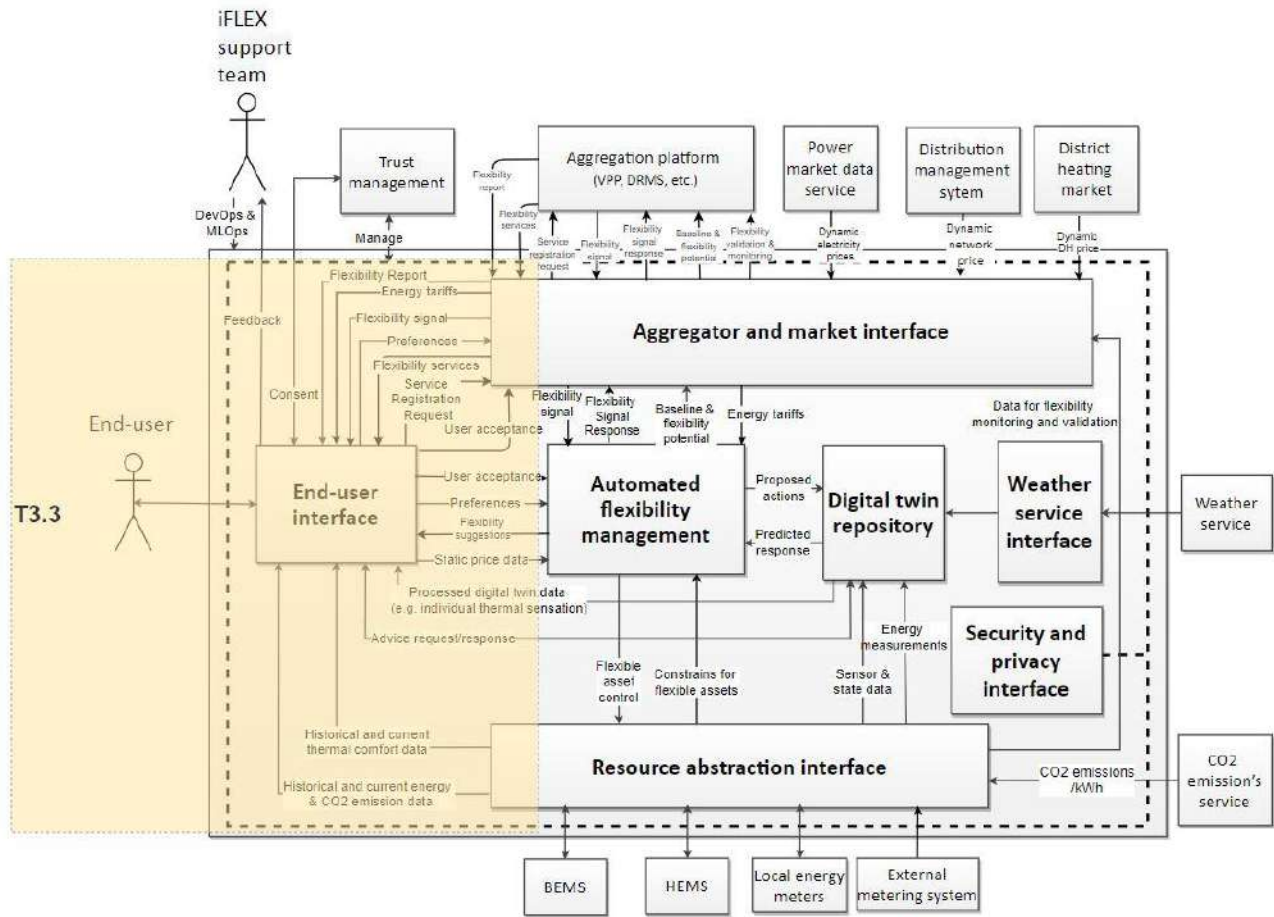


Figure 1: Functional view of the common iFLEX Framework [5]

2.4 Achievements of 1st and 2nd phases

The achievements of Phases 1 and 2, which are relevant to the UI, are reported in this section via a concise description of the supported functionalities per pilot, as well as references to the respective requirements. A more detailed description of all the UI-related requirements can be found in the Appendix (section 7.1) of this deliverable.

2.4.1 Greece

The application developed for the purpose of the Greek pilot enables the users to choose the level of automation of energy management realised by iFA, by activating or deactivating auto mode (FN-UI-05), as well as by customising and activating scheduled and flexible operation modes according to their will and preferences (FN-UI-01). While editing these modes, the users are able to provide the iFA with their time and operational constraints (FN-UI-02). Moreover, the iFA end users can select the objectives, upon which the energy optimisation of their premises is based (FN-UI-04). Furthermore, the users can view through the app their energy tariffs (FN-UI-17), and submit feedback on their experience while using the application (FN-UI-03).

As regards the Demand Response (DR)-related functionalities of the UI, the iFA provides its users with the ability to impose both temporary and permanent pause on DR – as well as on other types of – notifications (FN-UI-09). When auto mode is disabled, DR event notifications (FN-UI-21) are presented to the users, who are subsequently asked to provide their acceptance for the system-proposed schedules concerning their flexible assets (FN-UI-08). Finally, the users are able to inspect their DR participation history (FN-UI-22) via their iFA. The application was built as a responsive web application.

2.4.2 Slovenia

The described functionalities in the previous sub-section for the Greek pilot are also supported by the prototype mobile application, which has been developed for the Slovenian pilot of iFLEX. Moreover, the end users in Slovenia have the ability to monitor their real-time (FN-UI-11) and past energy data (FN-UI-12). The application was built as a native mobile application, and it will be distributed to the users in the Slovenian language (FN-UI-07) to facilitate their interaction with it. Furthermore, a walkthrough of the application is available in-app in order to explain to the users the functionality of each page whenever they want (NF-UI-03).

2.4.3 Finland

During the first phase, an initial version of the end-user interface for the residents of the building community was developed. The residents have access to their own building data with a specific web application. The CO₂ 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). Specifically, registered users have a possibility to have thermal sensors installed in their apartment, measuring temperature and humidity. Hence, registered users can view their own apartment's thermal data and their feedback on thermal comfort is addressed to their own apartment, whereas the feedback of other residents concerns the common areas of the building.

In Phase 2, the focus was on extending the UI with improved user experience and new functionalities. More specifically, the UI design updates for the Finnish pilot restructure visualisation of measurement data and expand user feedback to a separate form. Here is a detailed summary:

- All residents can register directly using a “Signup”-form, but measurement data will be visible only after the administrator has edited correct “access-codes” for the user in the user database.
- All measurement values have now longer time range in charts. The user can select from six predefined time ranges: one day, one week, two weeks, one month, six months and thirteen months.
- In addition to temperature and humidity, the apartment charts include now also CO₂ measurement data.
- The CO₂ emissions data are provided as a separate view.
- Electricity and district heating consumptions are available at the building level as separate views.
- The feedback is given from a separate view and includes now optional free text input and the option to set a referenced timestamp (for example: last Sunday at noon the apartment was too hot).

2.5 Focus of 3rd phase

The UI-related focus of Phase 3 is presented in this section. Thus, the UI features which should be supported by the end of the project are described, and the respective requirements are referenced.

2.5.1 Greece

In Phase 3, the UI should provide the iFA end users with insights into energy efficiency (FN-UI-14) and sustainability metrics (FN-UI-10). More specifically, the users should be able to set goals relevant to the above concepts and receive – if desired – customised alerts (FN-UI-15) on certain milestones of these goals, so that they can be assisted in achieving them. Furthermore, the users should be able to subscribe to an energy advising service, which will assist them in improving their energy performance via following customised advice per household (FN-UI-16). Moreover, the application should expose to the users the actual schedules of their assets (FN-UI-27) and not only their schedule preferences – as was the case previously.

The UI should be also equipped with a set of features presenting the various benefits that iFA end users gain via their iFAs. Hence, the users should be able to access through their UI the information retrieved from DR reports (FN-UI-13) with respect to their performance in explicit DR events, including their remuneration – economic or not. Moreover, the UI should provide the users with an estimation of future energy costs for predefined periods (FN-UI-28). In addition to that, an estimation of the benefits gained from adopting iFA's suggestions should be presented to the users (FN-UI-29).

The above functionalities are relevant to the UI for both the Greek and Slovenian pilots in Phase 3. However, due to the integration of the iFLEX web app into the existing Heron's mobile app in the Greek pilot, some additional requirements arise. First, this integration should be completed within Phase 3, securing

interoperability between ICOM and Heron's solutions (NF-UI-01). Second, the Greek pilot users should be equipped with the ability to view their schedules even when offline (FN-UI-26), overcoming difficulties relevant to integration of the two UI solutions. Finally, Heron's mobile app should enable the users to view their real-time (FN-UI-11) and past energy data (FN-UI-12) upon request.

2.5.2 Slovenia

The described functionalities in the first two paragraphs of the previous sub-section for the Greek pilot should also be supported by the mobile application, which is deployed in the Slovenian pilot of iFLEX.

2.5.3 Finland

In the 3rd phase Savings View was added to the UI front page. Savings are calculated separately for energy cost, energy consumption and CO₂ emissions and show the decrease or increase percentage during a selected timespan (30, 60 or 90 days).

Phase 3 focuses also on a new interface targeted for the facility managers. The purpose of this interface is to visualise near real-time and historical measurements from the building for engineers managing the building.

2.6 Co-creation with end users

Co-creation with end users is considered to be an important aspect for the iFLEX project. Thus, several relevant activities have already taken place, while others are planned during the third phase. This section summarises the co-creation activities that pertain to the UI.

In Phase 1, the mock-ups of the applications developed for the Greek and Slovenian pilots were shared with all the partners of the iFLEX consortium, so that initial feedback regarding the design could be retrieved. This feedback was taken into consideration during the development of the prototype applications for the first phase. In the meantime, the recruitment of pilot users for Phase 1 started. Hence, the prototype applications for the Greek and Slovenian pilots were subjects to usability tests. For the purpose of these tests, the first prototype application was presented both to these users and to iFLEX partners during one-on-one interviews, so that feedback could be collected on the usability, design, and features of the prototypes. Their comments and suggestions were gathered in order to proceed accordingly to the second phase redesign, as well as to prioritise additional functionalities. For example, it was decided to introduce an on-boarding questionnaire, which can assist the users in setting up their profiles upon their first log-in to the app. The employed methodology and the results of these usability tests were documented in D7.5 [6]. With respect to the Finnish pilot, feedback from the residents on the indoor temperature was collected, so that it could be considered while responding to future DR events.

As regards the UI-related co-creation activities in Phase 2, the mock-ups on additional functionalities or redesigned screens were shared with potential users during two workshops, which were organised in Greece and Slovenia in the autumn of 2022, in order to receive their initial feedback prior to updating the application. The participants in the Greek workshop were also able to provide additional feedback through an anonymous online questionnaire that was distributed to them. Once the second version of the application was ready, it was tested through new usability tests, which were conducted in the spring of 2023. During these tests, pilot users in Greece and Slovenia provided their feedback on the most recent version of the application during one-on-one interviews and also by filling in a relevant anonymous online questionnaire. Both methodology and results of the usability tests of Phase 2, as well as subsequent modifications in the UI based on the participants' feedback, can be found in D7.6 [7].

In Phase 3, the pilot users in Slovenia and Greece will be able to submit their feedback through the application itself, based on their own experience with it. This feedback can be exploited for app modifications by the end of iFLEX, while it can also serve as a base for potential future enhancements or redesign of the application, considering also its post-project exploitation.

3 Implementation

This chapter concerns the implementation for the Natural User Interfaces' task (T3.3), so the focus lies on the UI component. Hence, different architecture views for this component are presented, as well as the UI design for the most recent version of the application in each pilot.

3.1 Context View

This section presents a high-level view of the UI component, presenting the functionalities that should be supported by the end of the project. The iFA's UI is considered as a mobile or web application – depending on pilot specificities – that will provide the end users with the following functionalities:

- Monitor energy consumption/generation within premises (FN-UI-11, FN-UI-12);
- Choose the desired level of automation by activating or deactivating auto mode (FN-UI-05), and by customising and activating scheduled and flexible operation modes - providing time and operational constraints (FN-UI-01, FN-UI-02);
- Select the objectives upon which energy optimisation of the premises will be based (FN-UI-04);
- Temporarily or permanently pause notifications (FN-UI-09);
- Receive DR event notifications (FN-UI-21) and provide acceptance for the iFLEX-proposed schedules concerning flexible assets (FN-UI-08);
- Receive DR reports (FN-UI-13), as well as access to DR participation history (FN-UI-22);
- Gain insights into energy efficiency (FN-UI-14) and sustainability metrics (FN-UI-10), and receive customised alerts on relevant goals (FN-UI-15);
- Receive tailored energy advice, which will assist in improving their energy performance (FN-UI-16);
- View energy tariffs (FN-UI-17), as well as an estimation of future energy costs (FN-UI-28);
- View an estimation of the gained benefits from adopting iFA's suggestions (FN-UI-29);
- View the actual schedules of assets online (FN-UI-27) and offline (FN-UI-26);
- Provide feedback (FN-UI-03) on the experience while using the app or on their comfort level;
- Choose the system interface language between English and native language (FN-UI-07);
- View an app walkthrough, which explains to them the functionality of each page of the app, whenever they want (NF-UI-03).

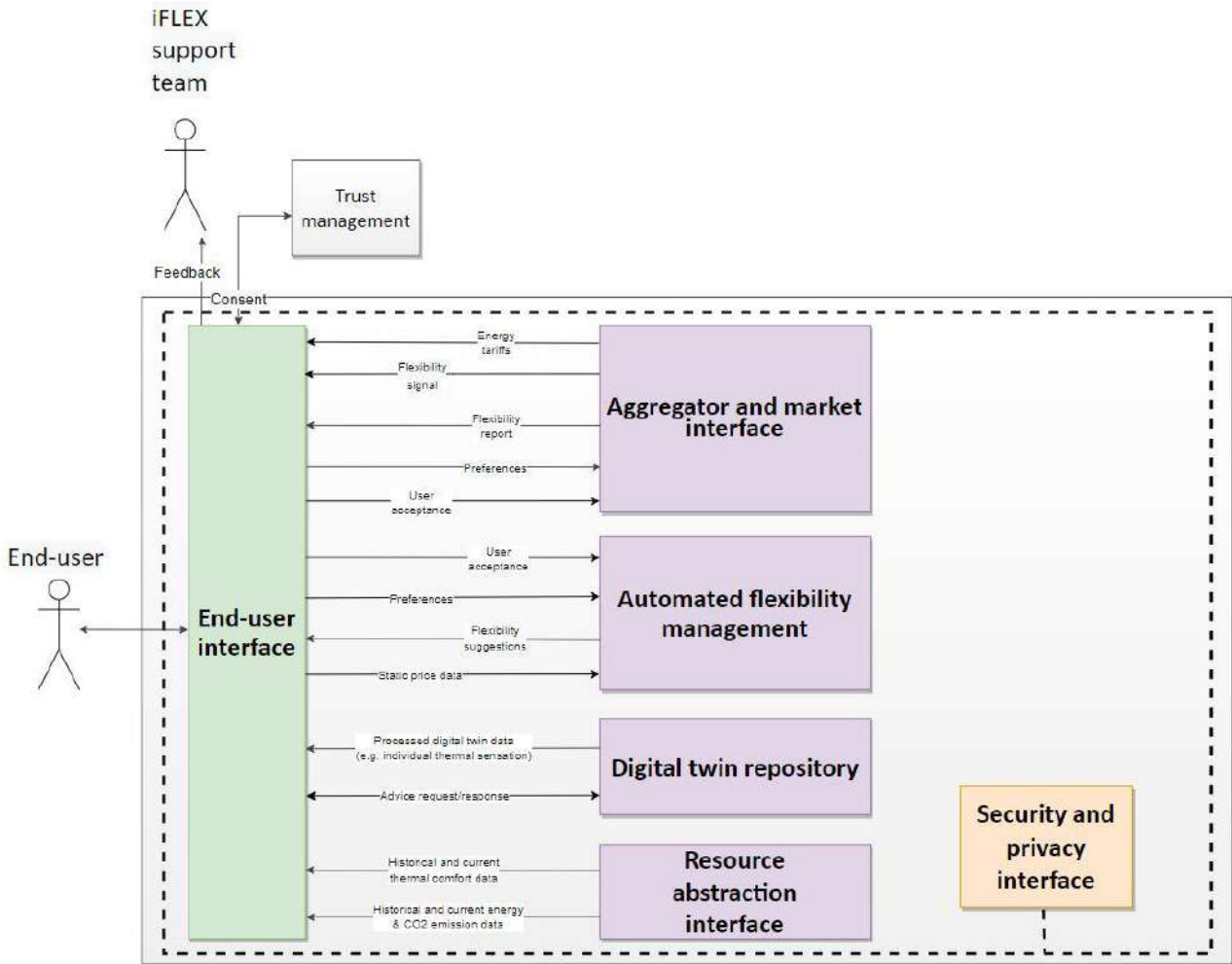


Figure 2: Context view of the UI module

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

- **Aggregator and Market Interface (A&M Interface):** The information flows with the A&M Interface concern DR-related signals, such as receiving flexibility signals and flexibility reports, and responding to flexibility signals. 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 user's response to a suggestion. Finally, the users might be able to add 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, CO₂ emission, and thermal comfort data from the RAI.

Figure 2 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.

3.2 Functional View

The main components of the iFA's UI module for the three different instantiations are documented in this section.

3.2.1 Mobile application for residential end users

This section presents the functional view of the UI in the Slovenian pilot (Figure 3). The frontend sub-components are the following:

- Admin Web Client: Intended to be used by site administrators – not by the actual users of the iFA. It is utilised during the development process to facilitate data testing, but can also be exploited in order to manage data in production.
- iFA Mobile Client: The iFA's UI is built as a hybrid mobile application. This application accesses and makes use of both the iFA backend for data updates and core service functionalities, as well as a mobile Local Secure Storage, which keeps data locally to enhance the end user experience.

As regards the backend, the utilised sub-components are as follows:

- End User Personalised Services: This sub-component equips the iFA end user with the ability to retrieve personalised data, such as asset schedules, objectives, past DR events, and notifications.
- Auth Services: This sub-component enables application-specific authentication and fine-grained authorisation and permission control on a user and group level.
- (Push) Notification Service: This sub-component is charged with generating and communicating push and in-app notifications to the iFA end users.
- Reverse Proxy/Load Balancer: This server is responsible for securing communications, as well as load balancing, session management and proper domain name matching.
- Cron Jobs/Async tasks: This sub-component handles the scheduling and execution of periodic or asynchronous tasks. For instance, a CronJob object is responsible for performing periodically a database clean-up. Examples of asynchronous tasks are supporting the user registration flow (e.g., by sending a registration email), and bootstrapping user's assets and other application-specific data models.
- Tasks Consumers: Dedicated event consumers are used to support data handling and long running tasks execution in a reliable manner. Consumers handle MQTT and AMQP messages.
- Tasks broker: An AMQP broker is utilised as event bus to support message exchange between backend services.
- Remote Database: The remote database ensures data persistence for all the backend data.

Finally, it is highlighted that the UI's backend needs to communicate with the backend of other iFA components (e.g., to receive an iFA-generated schedule suggestion, to send user's schedule preferences, etc.).

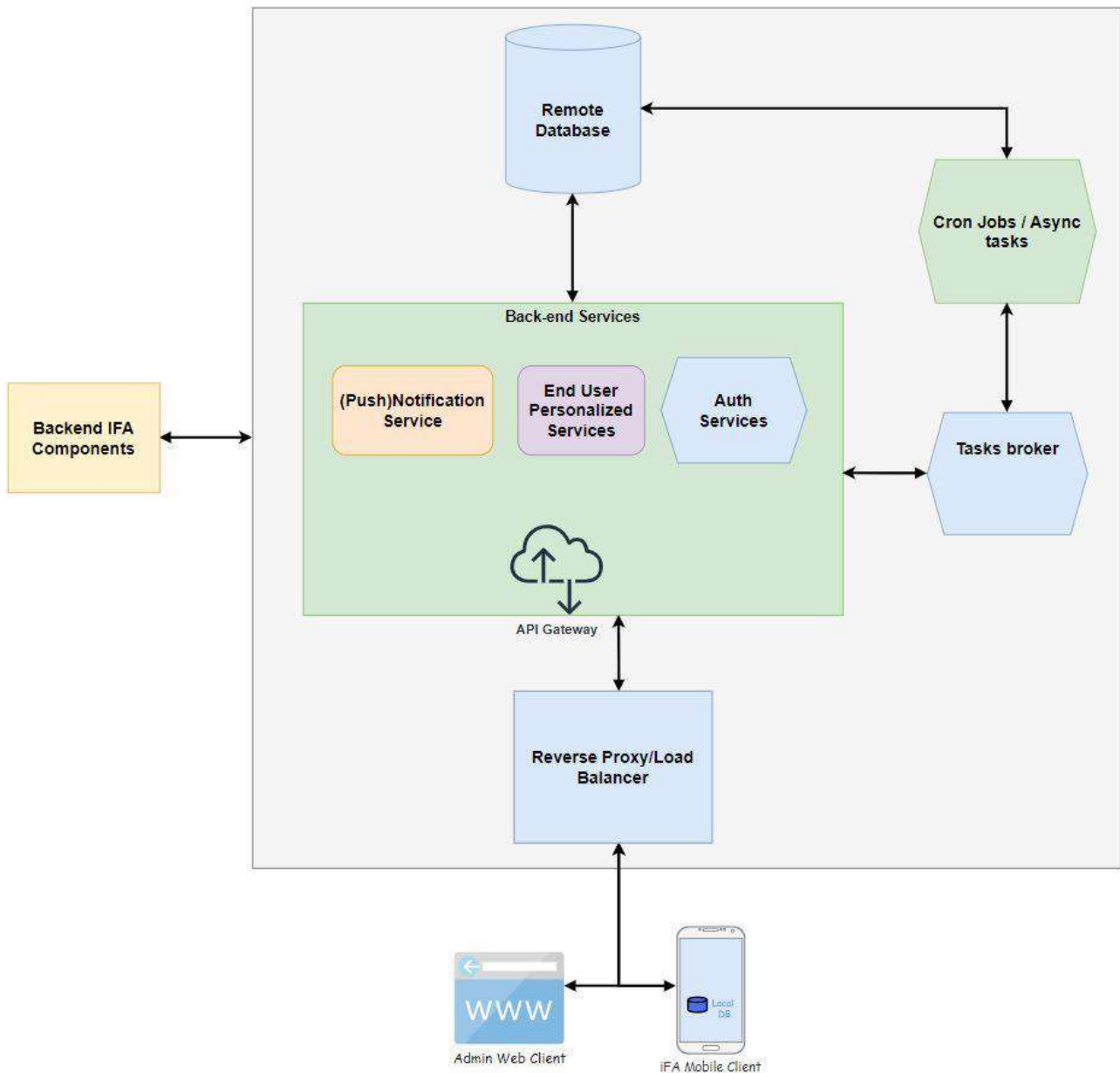


Figure 3: Functional view of the mobile app's UI component for residential end users in the Slovenian pilot

3.2.2 Web application for residential end users

This section concerns the functional view of the UI in the Greek pilot of the project (Figure 4), which is exposed as a web view through Heron's mobile app. As many sub-components are identical in both the Greek and Slovenian pilots, this section focuses only on their differences. As regards the frontend sub-components:

- **iFA Web Client:** The iFA's UI is accessible via this web client – either as a web view in the existing Heron mobile app or alternatively via a web browser.
- **Heron Mobile App:** The mobile app, which is developed by Heron for its customers. Additional functionalities, which are relevant to iFLEX, are exposed to the users via the iFA web client.

As concerns the backend, some functionalities are not part of the iFA's UI backend. More specifically, the (push) notification service sub-component is hosted instead by Heron's UI backend. Furthermore, an authentication and authorisation server, which is developed by a third party and provided by Heron, is exploited, whereas in the Slovenian pilot this service is hosted in the iFA's UI backend. Hence, the UI backend should also interact with these external sub-components.

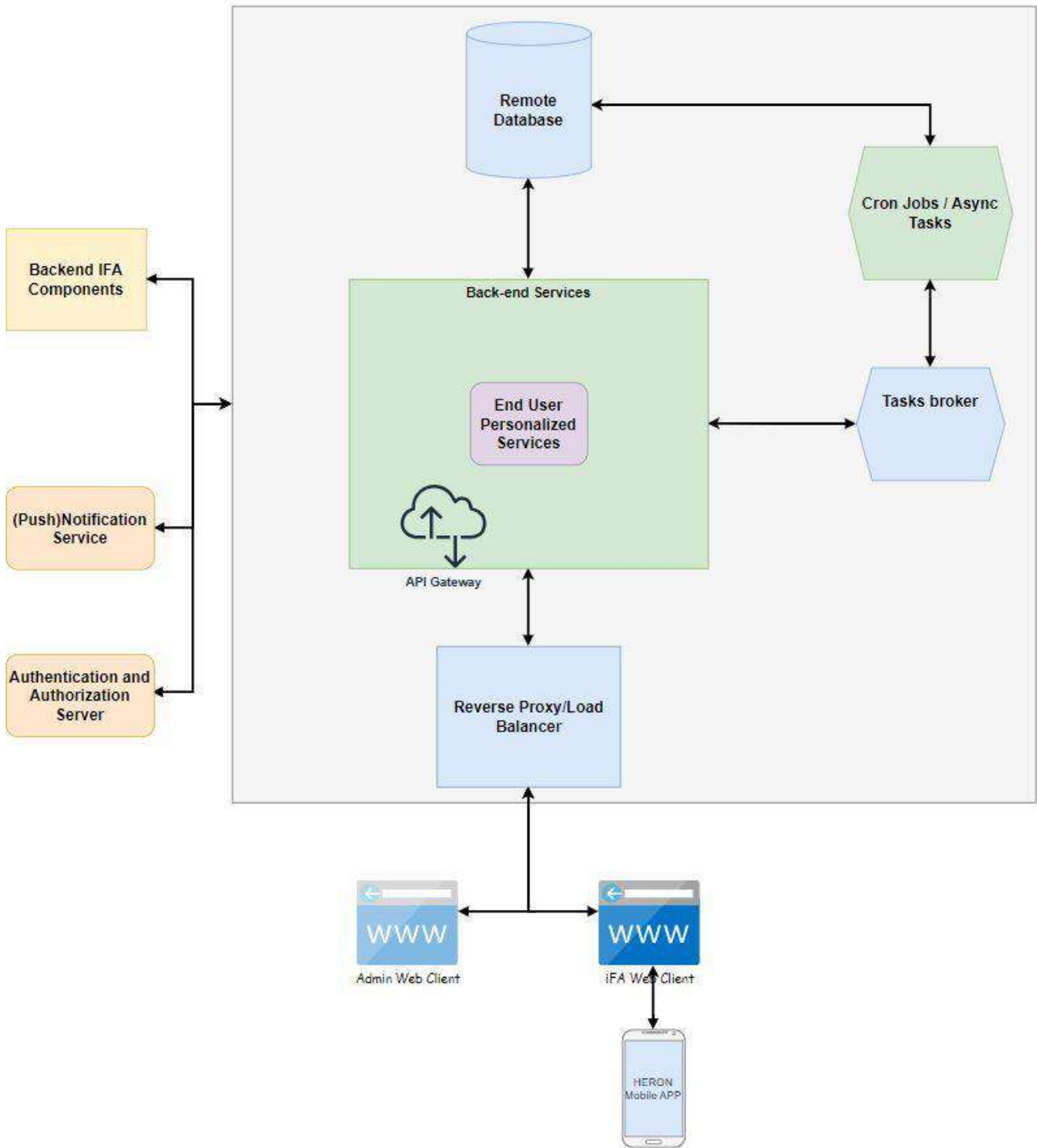


Figure 4: Functional view of the web app's UI component for residential end users in the Greek pilot

3.2.3 Building community

In the Finnish pilot, two types of users can be identified: residents and facility managers. For facility managers, we provide a UI created using Grafana [8], which is a multi-platform open-source analytics and interactive visualisation web application. For residents, a custom UI is built using standard and open-source web application techniques. The main components are illustrated in Figure 5.

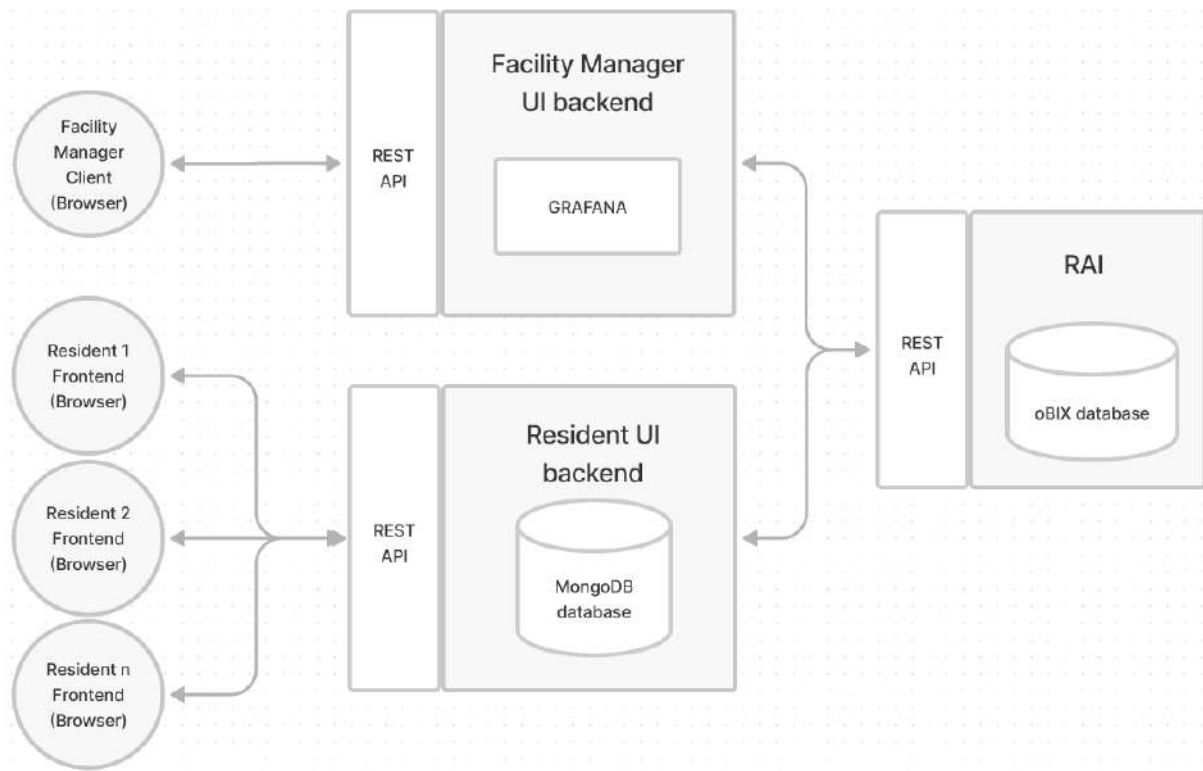


Figure 5: Functional architecture of the UI component for the building community in the Finnish pilot

3.3 Implementation View

This section documents the different instantiations of the UI component per pilot, exposing the technology stack employed in each one of them.

3.3.1 Greek pilot's UI instantiation

This sub-section outlines the iFA's UI component utilised in the case of the Greek pilot (Figure 6). Starting from the frontend, which is the presentation layer of the application, the Greek pilot's UI is built on a combination of frontend technologies. The iFA Application UI is accessible either through a web view in the existing Heron mobile application or directly through a web browser. The frontend makes use of HTML², CSS³ and various JavaScript⁴ libraries, React [9], React-router-dom [10] and styled-components [11] just to name a few.

The static files which complement the iFA presentation layer are served from a UI backend server based on the Django web framework [12]. The UI backend consists of multiple components which enable different functionalities for the end user. To secure and load balance requests on multiple server instances, a NGINX [13] web server is configured as reverse proxy. This server, apart from load balancing and proper domain name matching, handles secure communications with TLS termination⁵, Cipher suite⁶ enforcement and client authorisation with x509 certificates in case it is required, i.e., the administration panel.

As the base authentication and authorisation server, the third-party solution Keycloak [14] is utilised, provided by Heron. The client application makes a request to the backend with a JSON Web Token (JWT)⁷. The token is then introspected to Heron's Keycloak Auth server to verify its validity. If the verification is successful, the

² What is HTML?: https://www.w3schools.com/html/html_intro.asp

³ What is CSS?: https://www.w3schools.com/css/css_intro.asp

⁴ About JavaScript: https://developer.mozilla.org/en-US/docs/Web/JavaScript/About_JavaScript

⁵ TLS Termination for Network Load Balancers: <https://aws.amazon.com/blogs/aws/new-tls-termination-for-network-load-balancers/>

⁶ TLS Cipher Suites: <https://crashtest-security.com/configure-ssl-cipher-order/#tls-cipher-suites>

⁷ Introduction to JSON Web Tokens: <https://jwt.io/introduction>

user may access the exposed REST⁸ Application Programming Interface (API) to retrieve iFA personalised data (e.g., schedules, objectives, past DR Events, notifications).

Data persistence is achieved through a PostgreSQL database [15], while backend tasks propagation through different services is achieved through a RabbitMQ [16] message broker and a combination of publishers and subscribers that are built utilising the Pika [17] python package.

To be able to inform end users of required actions or alerts, a push notification service is utilised, provided by Heron. Upon an event reception from other iFA backend components, a task worker processes the event and creates a new notification. Depending on the user status (connected, disconnected), either an in-app notification is sent or a Push notification message is drafted and sent to the push notification server for further propagation to the end-user device.

⁸ Representational State Transfer (REST): An architecture style for designing loosely coupled applications over the network, which is often used in the development of web services. Relevant link: <https://restfulapi.net/rest-architectural-constraints/>

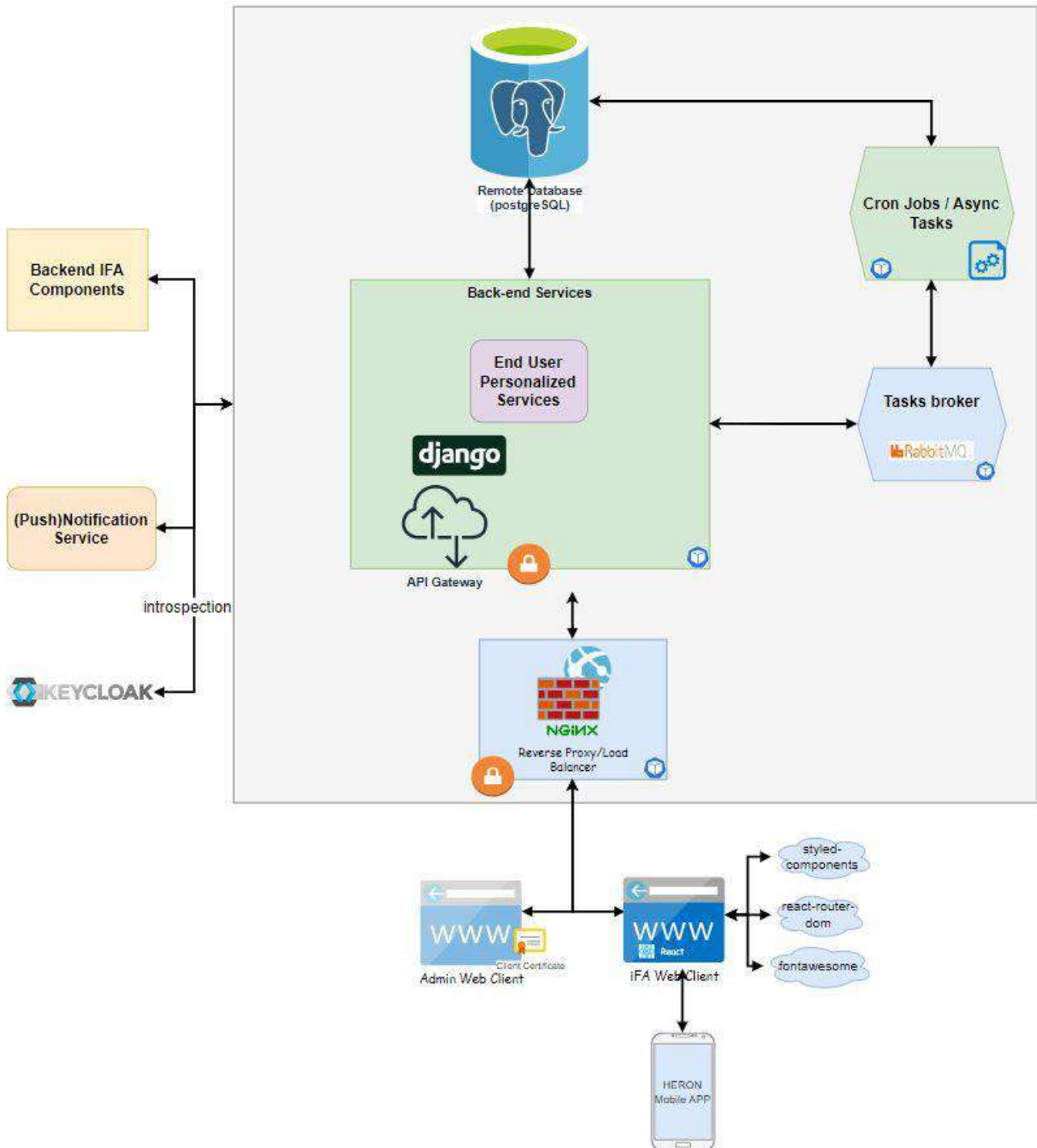


Figure 6: Technology stack of the web app’s UI component for residential end users in the Greek pilot

3.3.2 Slovenian pilot’s UI instantiation

The Slovenian pilot’s UI (Figure 7) makes use of almost the same building blocks and implements similar functionalities as the Greek pilot’s UI. There are three major differences compared to the Greek pilot’s UI instantiation of the previous sub-section.

The first concerns the utilised frontend technology and provided solution, which in the case of the Slovenian pilot is a hybrid mobile application instead of a web application. The mobile application is built using the React Native framework [18], a React-based framework which enables the development of applications for multiple

platforms using a single codebase. A number of third-party libraries, such as expo-secure-store [19], react-navigation [20] and react-native-paper [21], are utilised to provide the desired visual and functional outcome.

The second difference compared to the Greek pilot’s solution is the absence of the external Auth Server (Keycloak). Instead, the built-in Django Authentication and Authorisation services are utilised and extended with framework-specific python packages to enable token issuance and authorisation.

The third difference among the pilot-specific solutions is the “Push Notification Service”, which in the case of the Slovenian pilot is provided by ICOM. Push notifications are drafted and emitted from a service that is part of the Django application server.

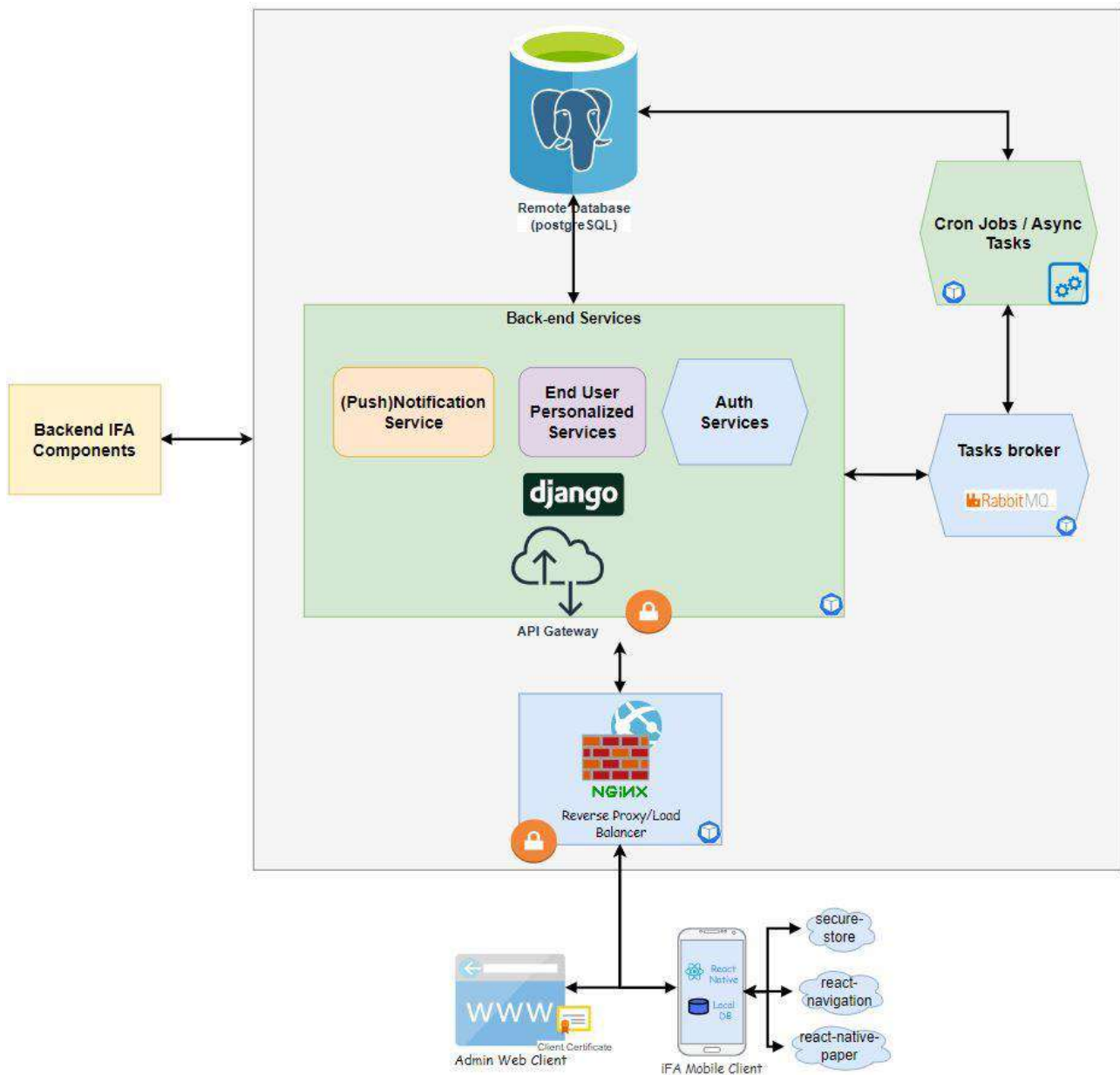


Figure 7: Technology stack of the mobile app’s UI component for residential end users in the Slovenian pilot

3.3.3 Finnish pilot's UI instantiation

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, HTML, SVG⁹ and CSS. It utilises modular programming techniques facilitated by ECMAScript 6 (ES6)¹⁰, MVC (Model-View-Controller)¹¹ and observer patterns. It is made with a Responsive Web Design (RWD)¹² approach, so it naturally supports different devices: smartphones, tablets, laptops and desktops, as shown in Figure 8.



Figure 8: The user interface supports naturally different devices

The application contains a backend and a frontend. The backend is written with Node.js [22], which is an open-source, cross-platform, JavaScript runtime environment that executes JavaScript code outside a web browser. The backend stores user data into a MongoDB database [23] and uses Mongoose [24], which provides a straight-forward, schema-based solution to model the application data. Almost all backend API calls are verified with JSON Web Token (JWT) to protect from unauthorised use. The JWT is created at server level and sent to client during successful log-in. Client stores and uses it in the following communication between client and server. A detailed description on how the backend is used as a proxy server for oBIX data requests can be found in D4.2 [25]. Figure 9 shows database models that are used in the iFLEX backend.

⁹ What is SVG?: https://www.w3schools.com/graphics/svg_intro.asp

¹⁰ Overview of ECMAScript 6: <https://262.ecma-international.org/6.0/#sec-overview>

¹¹ Model View Controller pattern: <https://en.wikipedia.org/wiki/Model-view-controller>

¹² Responsive Web Design – Introduction: https://www.w3schools.com/css/css_rwd_intro.asp

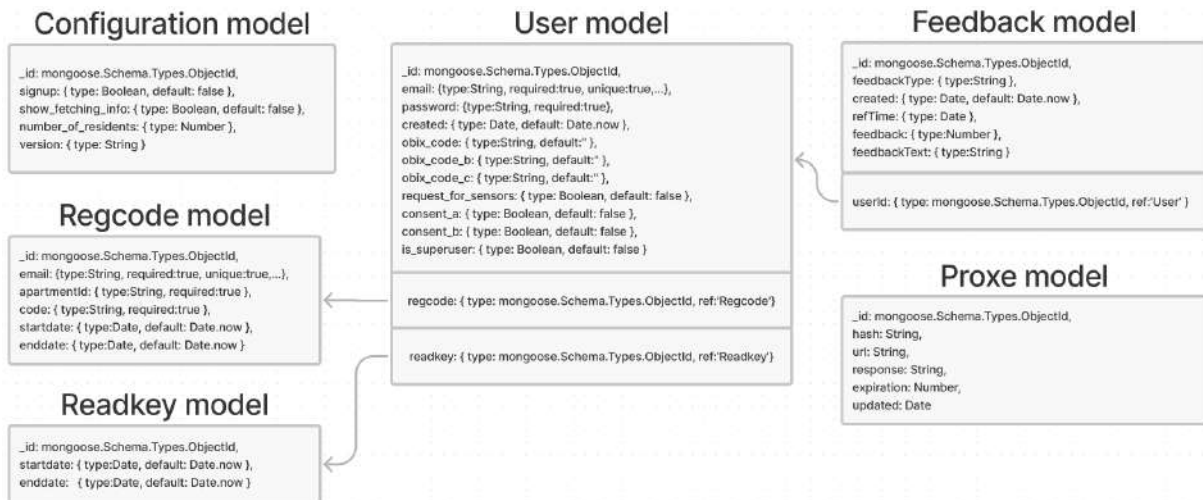


Figure 9: Backend models of the UI for the building community in the Finnish pilot

3.4 User Interface Design Updates

This section presents the up-to-date progress regarding the UI Design of the iFA. First, the solutions for individual end users are exhibited. Then, the work on the UI of the building community is shown.

3.4.1 Mobile application for residential end users

The application that was developed for the purpose of the Slovenian pilot, which is operated by ECE, is documented in this section.

3.4.1.1 App Initiation

In order to acquire access privileges and be able to navigate to all application pages, the user needs to log in using personal credentials, as presented in Figure 10.

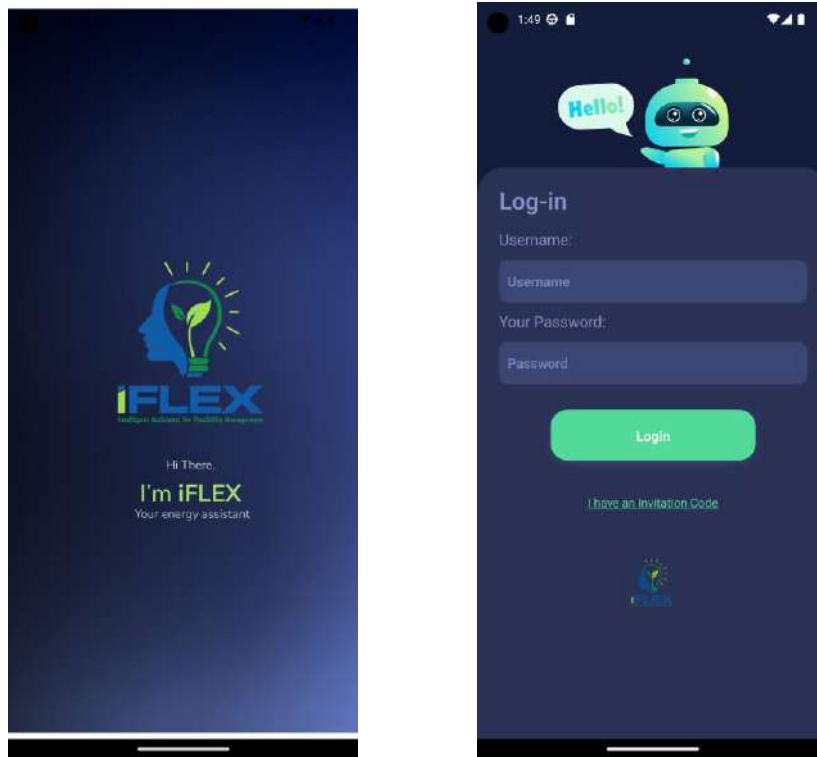


Figure 10: Mobile app – Splash and log-in screens

3.4.1.2 Dashboard

Once the user successfully logs into the application, the landing screen is the “Dashboard” screen (Figure 11). In the main menu, which can be found in the lowest part of every screen, the options “DR Events”, “Advice”, “Energy”, “Costs” and “Settings” are available. In the navigation bar at the top of the screen, there is a back button (when applicable), the notifications and the user profile.

In the “Dashboard” screen, the users can see an overview of key facts on their energy consumption, operation of their assets, and their energy goals. By selecting the “View more” button in each one of the above categories, the users are directed to the dedicated pages of the app, which are presented below.

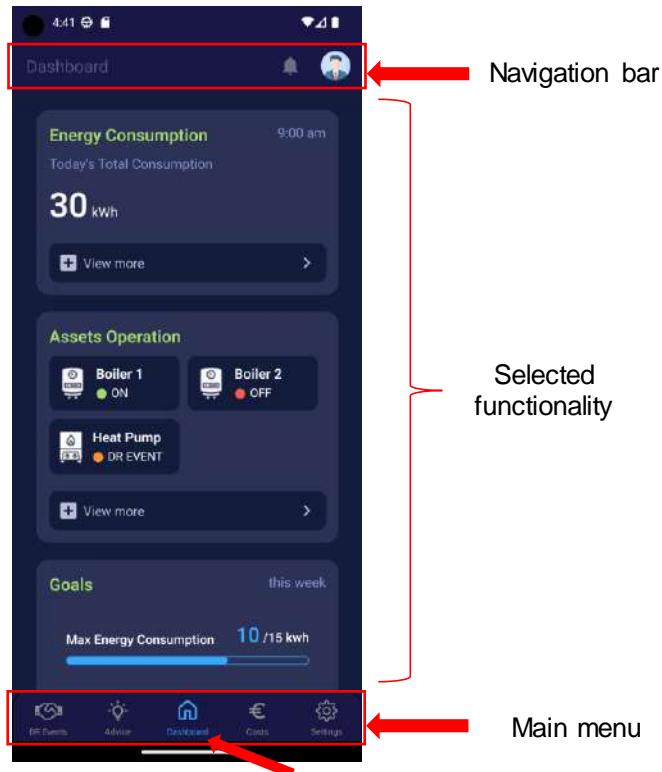


Figure 11: Mobile app – “Dashboard” screen

In the “Energy Consumption” screen (Figure 12), 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 day, 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 it, the users can hide data from the graph, so that they can focus on the consumption of specific assets for the desired time period.



Figure 12: Mobile app – "Energy Consumption" screen

In the “Assets Operation” screen (Figure 13), the users can view the schedules of their flexible assets. More specifically, by selecting a past date, the actual schedules of the assets on that day are presented. In case a future date is selected, the scheduled operation of the assets is exhibited based on the most recent information.

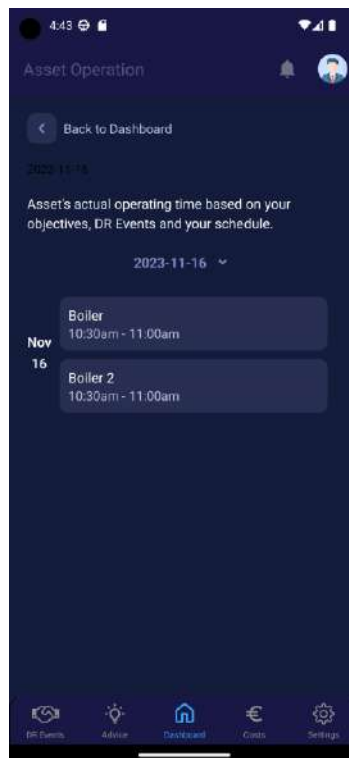


Figure 13: Mobile app – “Assets operation” screen

In the “Goals List” screen (Figure 14), the users are able to set weekly and/or monthly goals, which will assist them in improving their energy performance. If desired, it is also possible to set a relevant alert for each one of the goals, so that notifications are sent to the users at certain milestones. Hence, tracking of the goal is easier in order to facilitate the users to finally achieve it.

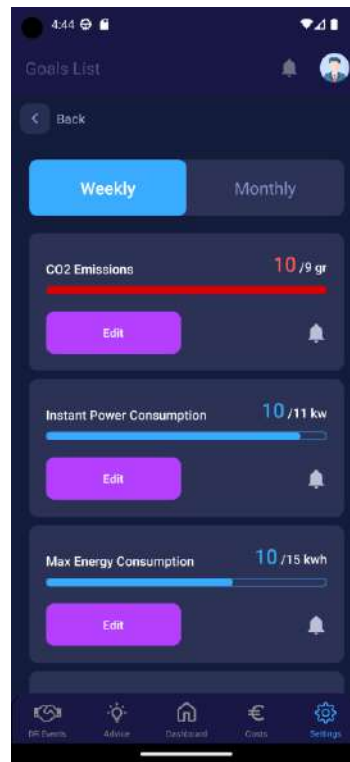


Figure 14: Mobile app – “Goals List” screen

3.4.1.3 Settings

In the main menu found at the lowest part of the screen, when selecting the fifth option which is called “Settings”, users are directed to the screen shown in Figure 15. In this screen, users are able to access the settings menu. In the settings menu, options such as “Preferences”, “Push Notifications” and “Goals List” can be accessed. The functionality of “Goals List” is presented in the previous sub-section, as it can be reached also through the app’s dashboard. In the “Preferences” option, there is a sub-menu with the options “My Objectives” and “My Schedules”. Respectively, in the “Push Notifications” option, there are two sub-options: “Silence Rules” and “Temporary Silence”.

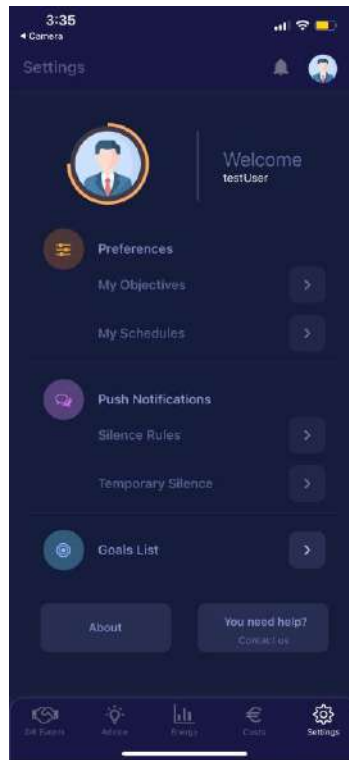


Figure 15: Mobile app – “Settings” screen

Selecting the first option “My Objectives”, users are directed to a screen where they can select their optimisation policy. This way, the iFLEX Assistant will make decisions while trying to accomplish the user’s objectives. The relevant screens can be seen in Figure 16.

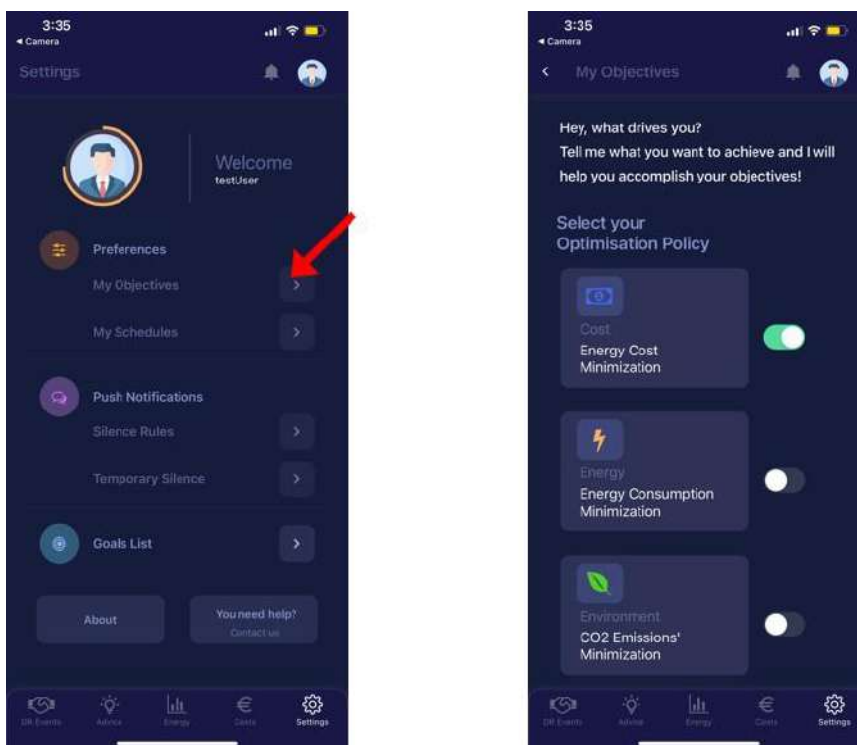


Figure 16: Mobile app – “My Objectives” screen

Back to settings, when selecting the second option called “My Schedules”, users can find all the schedules they have set, as shown in Figure 17. According to the most recent information on the flexible assets of the pilot users in Slovenia, each user may have one or more heat pumps that can be used also to offer flexibility to interested market actors. Hence, this screen was redesigned to align to the users’ needs, as described by the Slovenian cluster of the iFLEX project. In this screen, there is one “schedule” per heat pump. The “schedule” can be activated and deactivated whenever the users want. This “schedule” actually sets the range of acceptable operation for the heat pump, based on its temperature. More specifically, the users are able to define the minimum, preferred, and maximum temperatures for each one of their heat pumps. These temperature setpoints are considered by the iFA while devising the operation schedule of these assets.

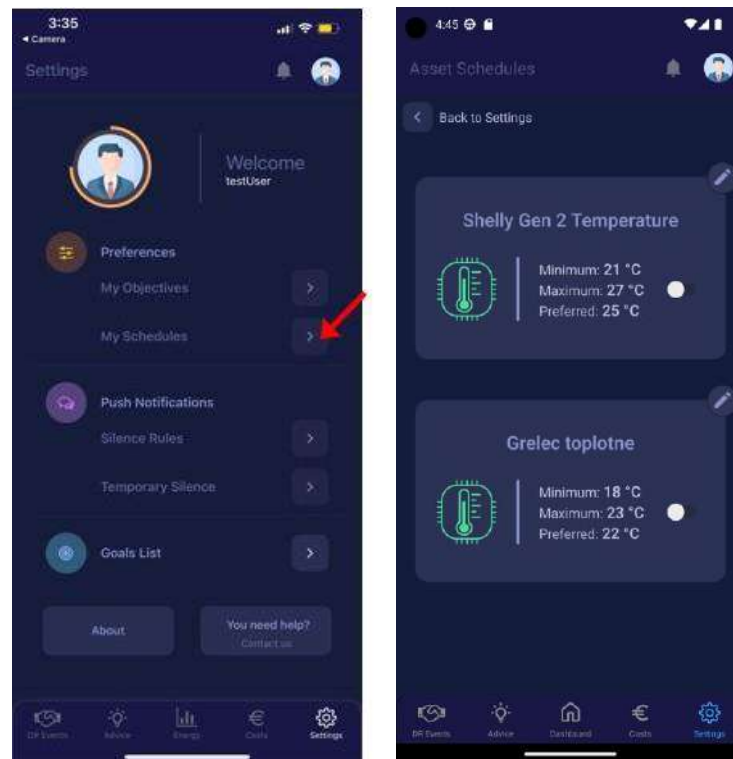


Figure 17: Mobile app – “My Schedules” screens

Heading back to the general settings menu, when selecting the third option called “Silence Rules”, the saved silence rules are displayed (Figure 18). A silence rule includes a silent period during which the user will not receive any push notifications. If users want to add a new silence rule, they will have to fill in two fields; one for the days and the other for the hours that the silent period will be activated. When all the fields are filled, the user selects “Set silent period” and the silent period is saved and activated.

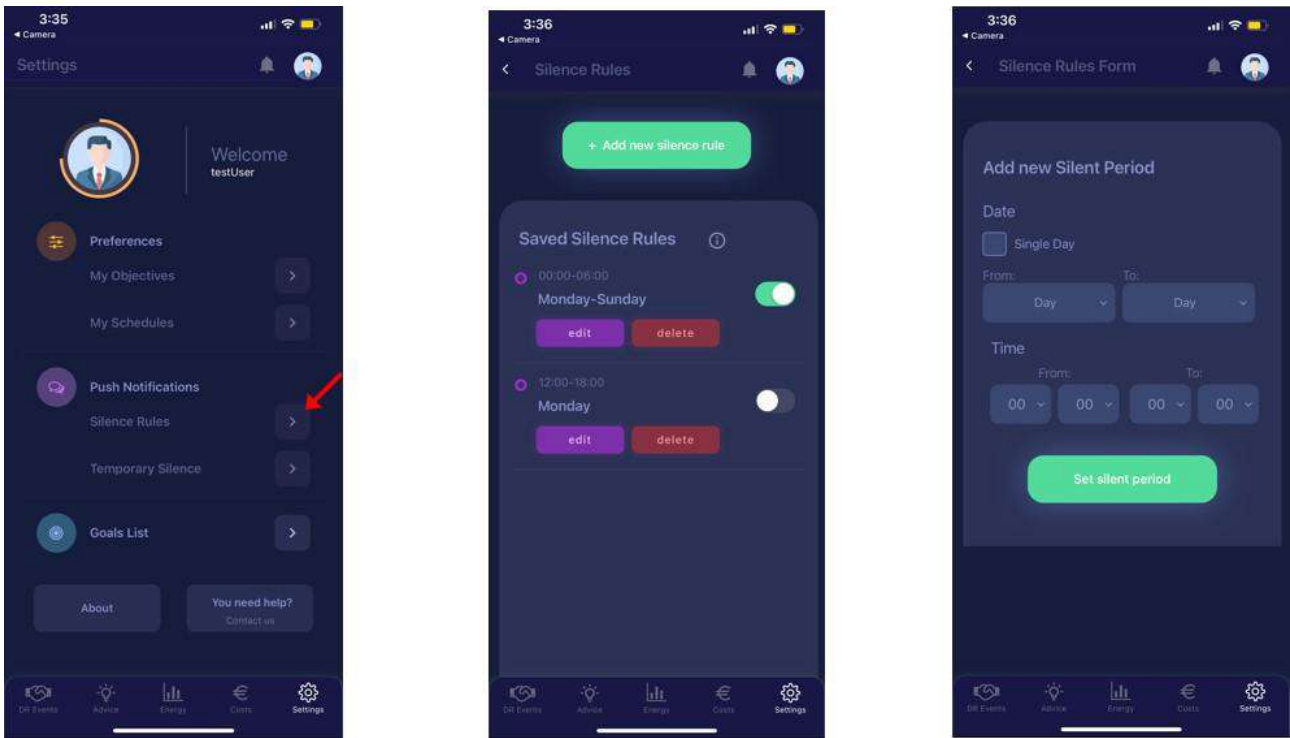


Figure 18: Mobile app – “Silence Rules” screens

Back to settings, when selecting the fourth option called “Temporary Silence”, users can mute temporarily all the push notifications, as shown in Figure 19. Push notifications are messages that pop up on a mobile device. iFA can send them at any time; users don’t have to be in the app or using their devices to receive them. Such notifications are used to convey information about new DR events, to notify about alerts, etc.

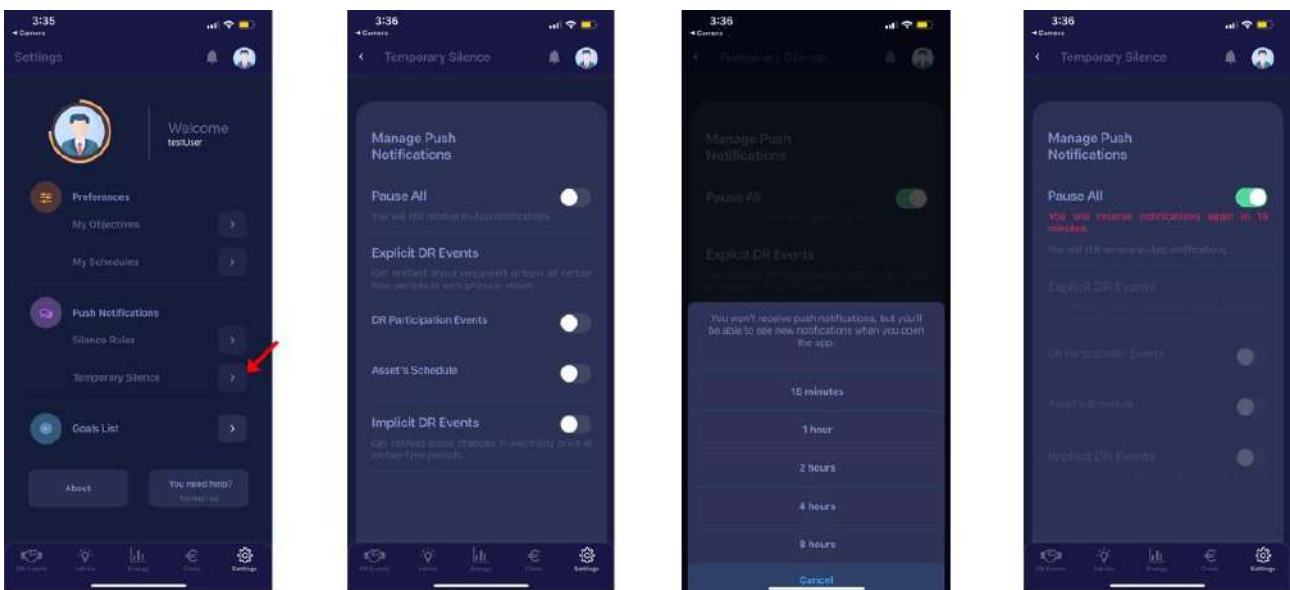


Figure 19: Mobile app – “Temporary Silence” screens

In the lower part of the General Settings screen, the user can find general information about the iFLEX project, the iFA, and the app, as well as a help centre. These screens are shown in Figure 20.

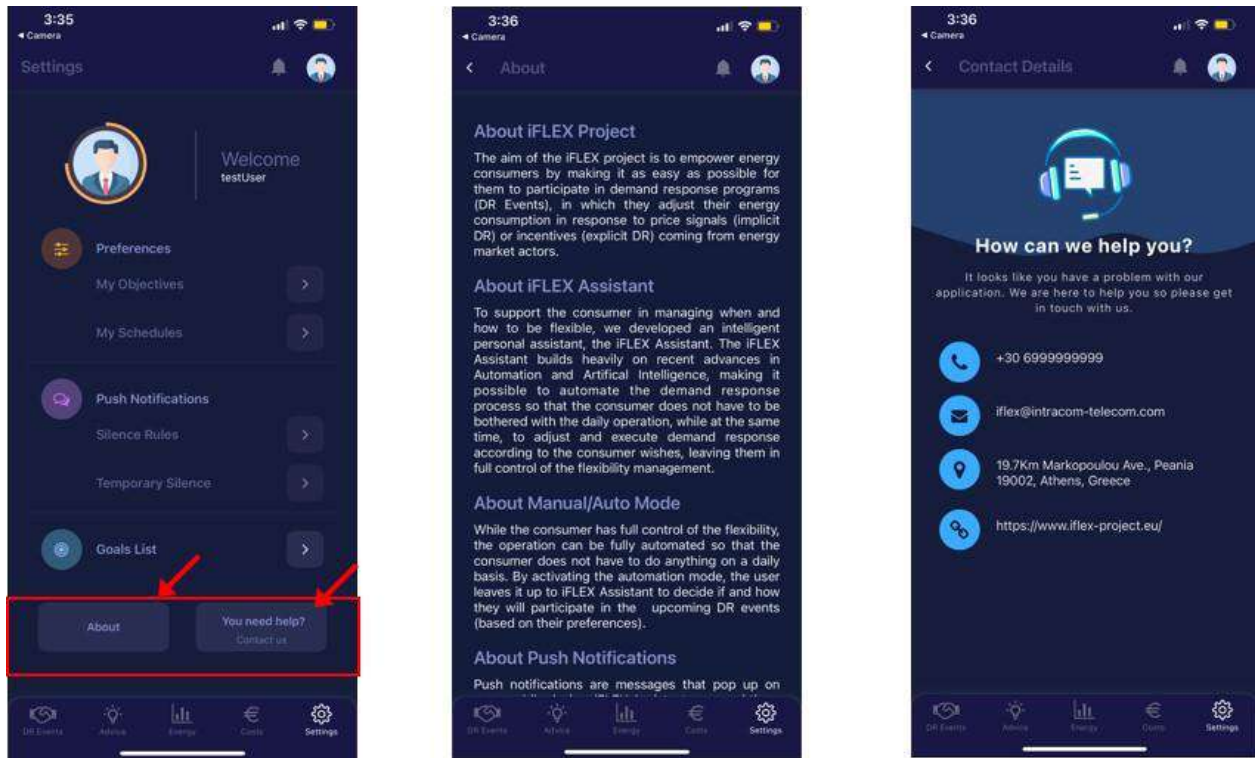


Figure 20: Mobile app – General Information and Help Centre screens

3.4.1.4 DR Participation

In the main menu, which is found at the lowest part of the screen, when selecting the first option which is called “DR Events”, users are directed to the screen shown in Figure 21, where they can check their DR participation history and details about each event. In addition, the user is informed about the action taken in order to participate in the specific DR event and whether the decision to participate was made automatically (i.e., from the iFA) or manually. Users can see not only the DR events in which they have participated in the past, but also those that they have rejected. At the top of this screen, users can see the total points earned through participation in explicit DR events. Here, an approach based on a reward mechanism is presented, according to which users 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.

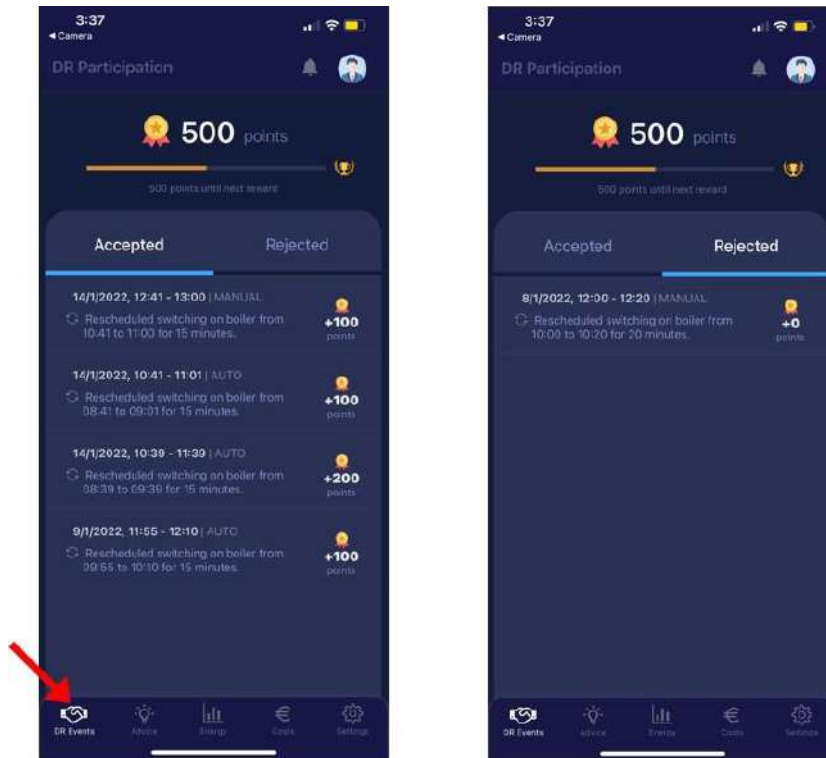


Figure 21: Mobile app – “DR Events” screens

3.4.1.5 Costs

In the main menu found at the lowest part of the screen, when selecting the fourth option that is called “Costs”, users are directed to the screen shown in Figure 22. The structure of this screen is identical to the Dashboard, which is presented in a previous sub-section. However, in this case, the information exposed in this screen is relevant to economic aspects. The three sections are “My Tariffs”, “Costs Estimation”, and “My Savings”. Key data on each one of these features can be seen directly in this screen, while the users can select the “View more” button, so that they can view more details regarding the feature in which they are particularly interested.

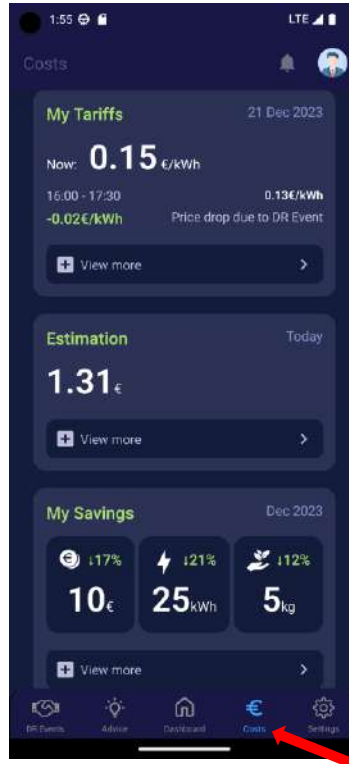


Figure 22: Mobile app – “Costs” screen

By selecting to view more information regarding the tariffs, the users are directed to the relevant page, as shown in Figure 23. In this screen, the currently active tariff is outlined, while the users can also see a graph about the fluctuation of the electricity price throughout a day of their choice. Furthermore, a list of the upcoming implicit DR events is shown, highlighting their active period, actual tariff during this period, as well as the variation compared to the normal tariff (i.e., without any active implicit DR events).



Figure 23: Mobile app – “My Tariffs” screen

In the “Costs Estimation” screen (Figure 24), the users are provided with an estimation of their upcoming energy costs for this and the following day. It is noted that this estimation concerns the costs linked directly to the users’ consumption and tariffs at each time interval. Indirect costs, such as fees for RES, taxes, etc., are not considered.

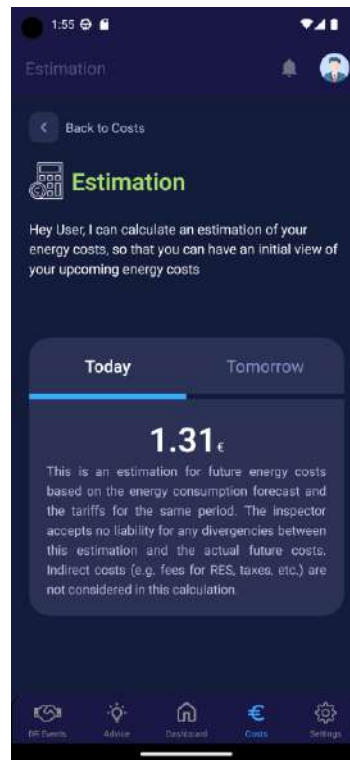


Figure 24: Mobile app – “Costs Estimation” screen

In the “My Savings” screen (Figure 25), the users are able to view their calculated savings thanks to the operation of the iFA (e.g., adoption of iFA’s suggestions, participation in DR events, etc.). These savings concern energy costs, energy consumption, and CO₂ emissions. Both their actual values and the percentage variation compared to the operation without iFA’s interventions are presented at an aggregated level for a month. The users can select the month for which they would like to see the relevant statistics.



Figure 25: Mobile app – “My Savings” screen

3.4.1.6 Advice

In the main menu found at the lowest part of the screen, when selecting the second option that is called “Advice”, users are directed to the screen shown in Figure 26. The presented examples in this figure concern either the operation of certain assets or the potential replacement of a highly consuming asset. The aim in both cases is to improve the energy performance of the users. Since the task on energy advice is a work in progress, there might be some variations (e.g., extension of scope relevant to energy costs, etc.) to the approach presented here by the end of the project.

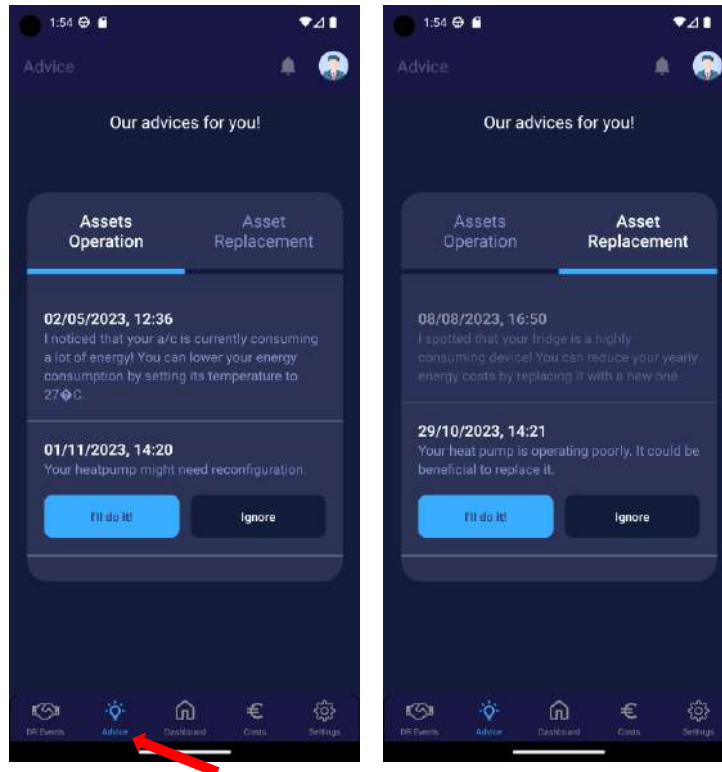


Figure 26: Mobile app – “Advice” screen

3.4.1.7 Auto Mode

In the menu found at the top of the screen, when selecting the “user” icon, users are directed to the screen shown in Figure 27 where they can manage their profile settings. When the “Auto Mode” is off, the user has full control of the energy and flexibility management. When the “Auto Mode” is on, the operation of the iFA is fully automated and the user does not have to do anything on a daily basis. Any actions taken by the iFA will be communicated to the user via in-app and push notifications.

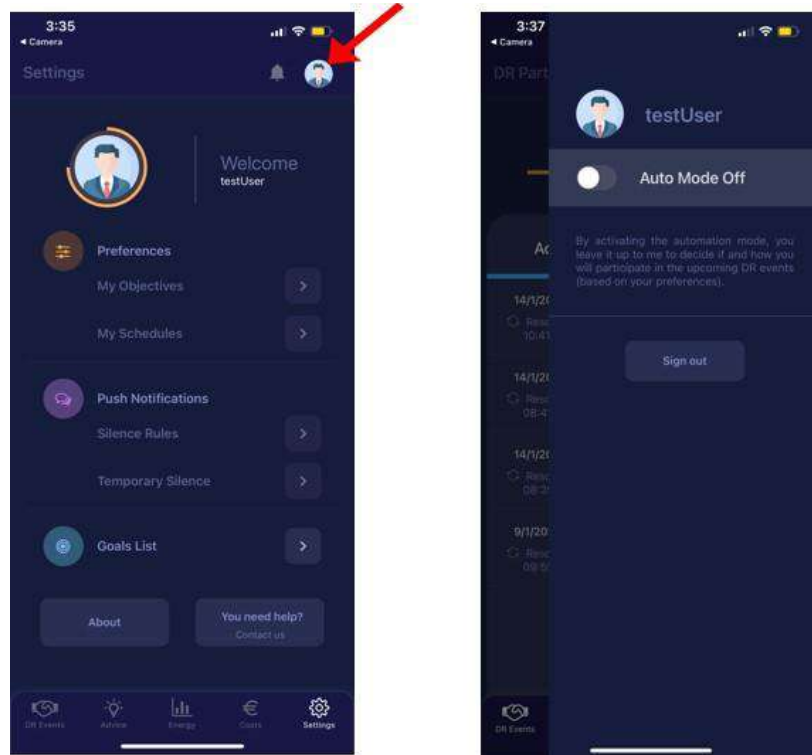


Figure 27: Mobile app – Activation of Auto Mode

3.4.1.8 Notifications

In the menu found at the top of the screen, when selecting the bell icon, users are directed to the screen shown in Figure 28, where they can check their various notifications.

For example, when receiving a notification about an explicit DR event, this means that the users have to change their consumption accordingly in order to participate – if desired – in that DR event. The users are notified of an upcoming explicit DR event 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 iFA 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 iFA 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 the iFA failed to find an acceptable solution.

In Phase 2, filtering of notifications based on their category was added to the app. For instance, if the users want to focus during a session on the notifications related to DR events, they can apply this filter, so that only notifications of this type will be shown in the “Notifications” screen.

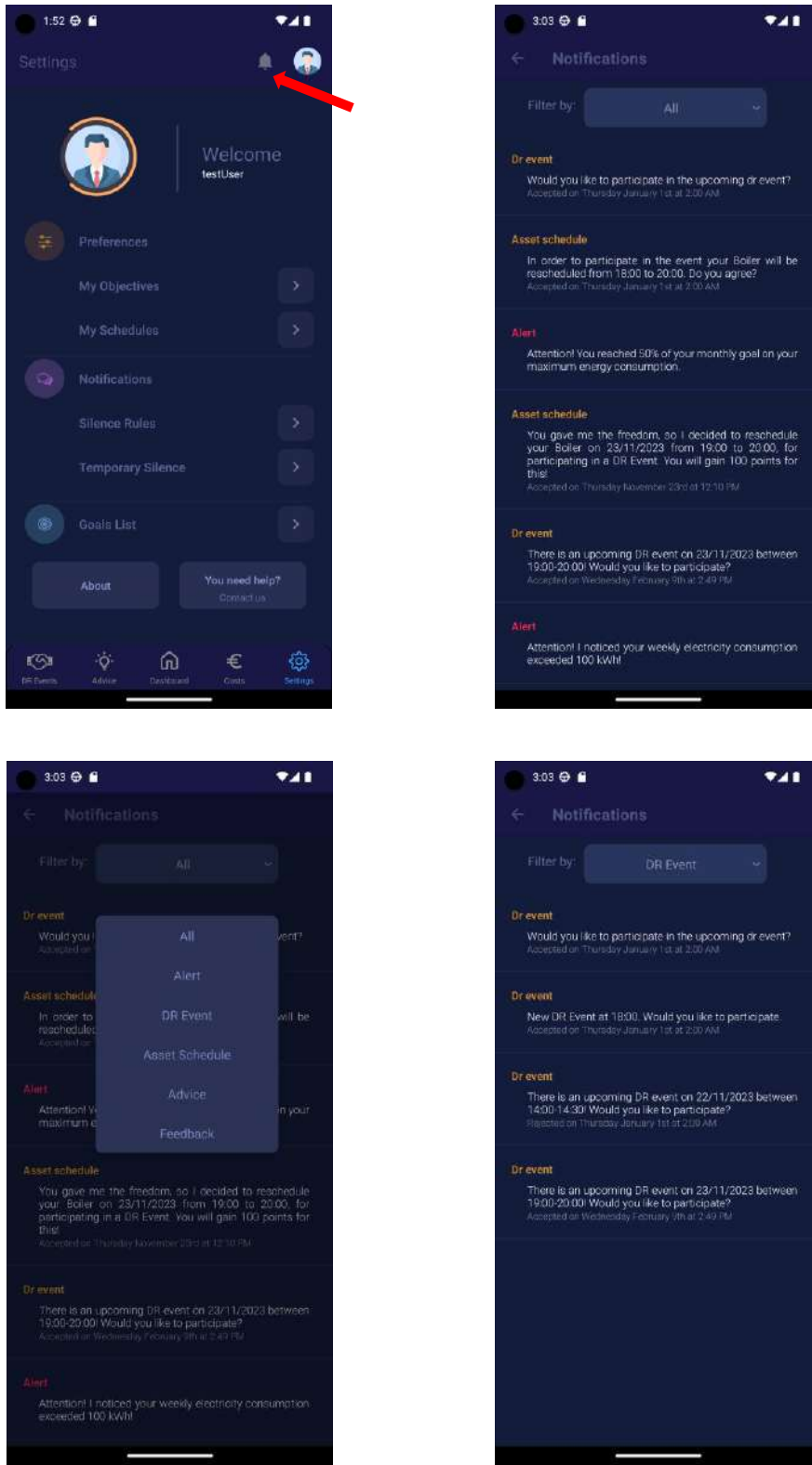


Figure 28: Mobile app – “Notifications” screens

3.4.1.9 App Walkthrough

Finally, an app walkthrough has been prepared, which guides the users through all the pages of the application, so that they can understand their functionalities. This walkthrough will be presented to all the users during their first log-in on the app, and also upon request by selecting the “Start Tutorial” option in the “User Profile” screen.

Hence, whenever a user would like to be reminded about the app features, this is possible thanks to this walkthrough. A sample of the walkthrough's screens can be seen in Figure 29.

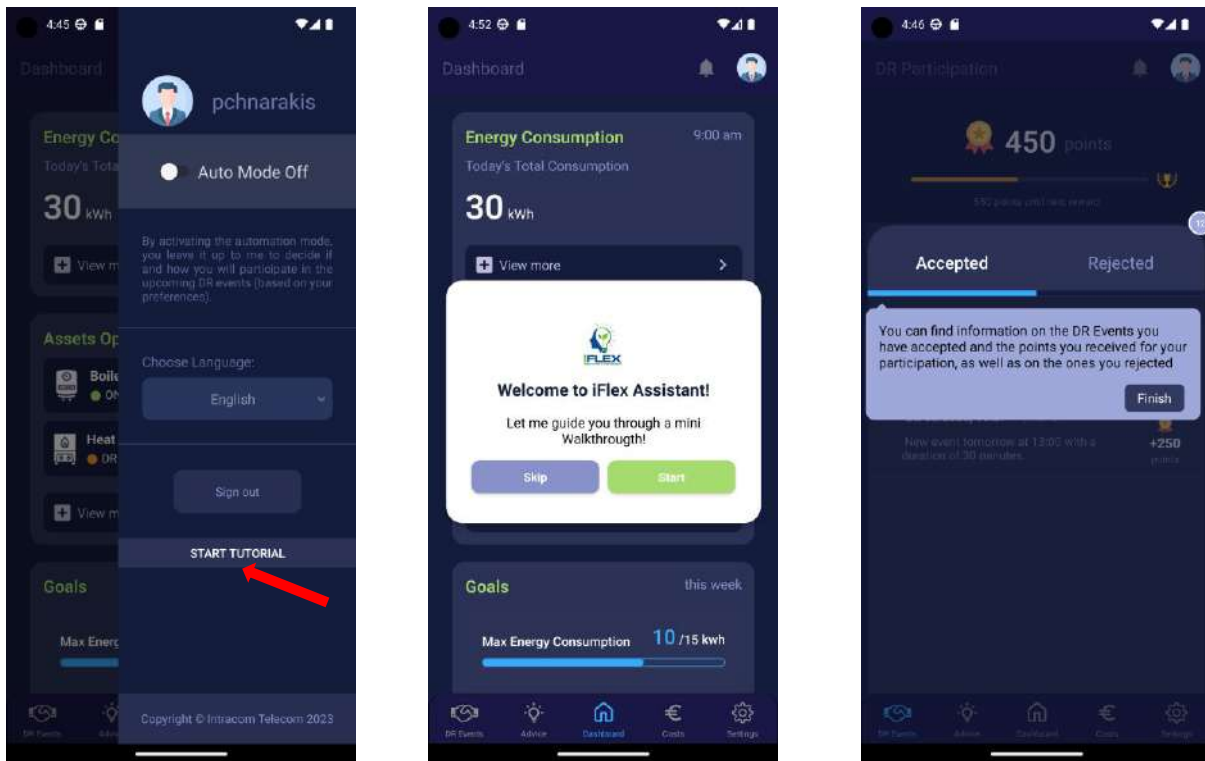


Figure 29: Mobile app – “App walkthrough” screens

3.4.2 Web application for residential end users

The Greek pilot's case, which is operated by Heron, is presented in this section. As the functionalities supported by the web app are also described in the section concerning the mobile app (3.4.1), more details on the various features can be found there. The scope of the current section is to show the UI design of the web app and the navigation within it. Additionally, if a screen of the web app differs from the respective screen of the mobile app (e.g., “My Schedules”), the functionality of the web app is detailed in this section.

3.4.2.1 App Initiation

The user initially interacts with Heron's mobile application and can be swiftly redirected to the iFA's web application, which supports the additional iFLEX-related functionalities, via selecting the relevant button at the bottom right of the screen (Figure 30). Thus, increased user experience is secured, as the pilot users can continue using the same application that they have become accustomed to. It is also noted that the UI design of the iFA's web app is tailored to the design of Heron's mobile app, so that the user experience is further improved through recognition thanks to the common design adopted by both applications.



Figure 30: Heron's mobile app – Log-in screen and redirection to the iFA's web app

3.4.2.2 Dashboard

Once the users have logged in to the iFA's web app, they land on the “Dashboard” page (Figure 31). As in the case of the mobile app, this page presents key data on energy consumption, assets operation, and energy goals. The users can view more about the last two sections by selecting the relevant buttons. A dedicated page for energy consumption is not included in this case, as the users can access such information through Heron's mobile app.

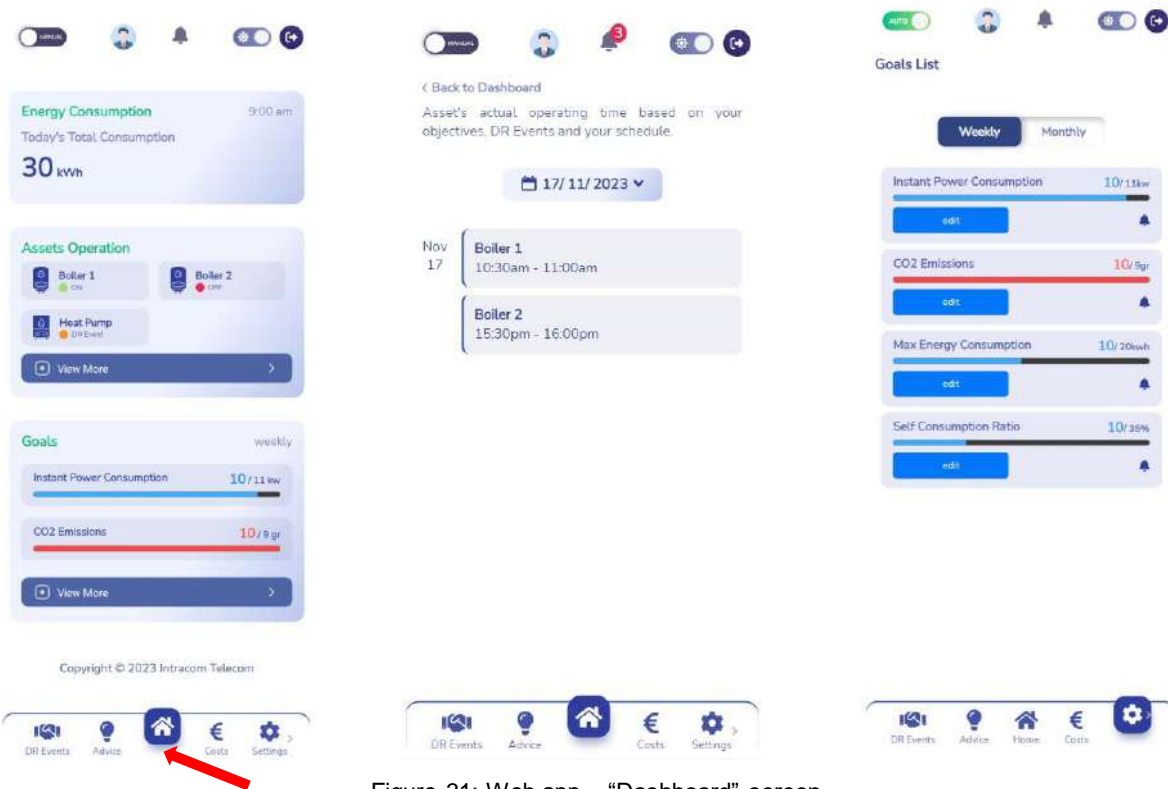


Figure 31: Web app – “Dashboard” screen

3.4.2.3 Settings

Once the users have logged in to the iFA's web app, they can access and modify their optimisation objectives by selecting "Settings" and subsequently "Preferences", as shown in Figure 32.

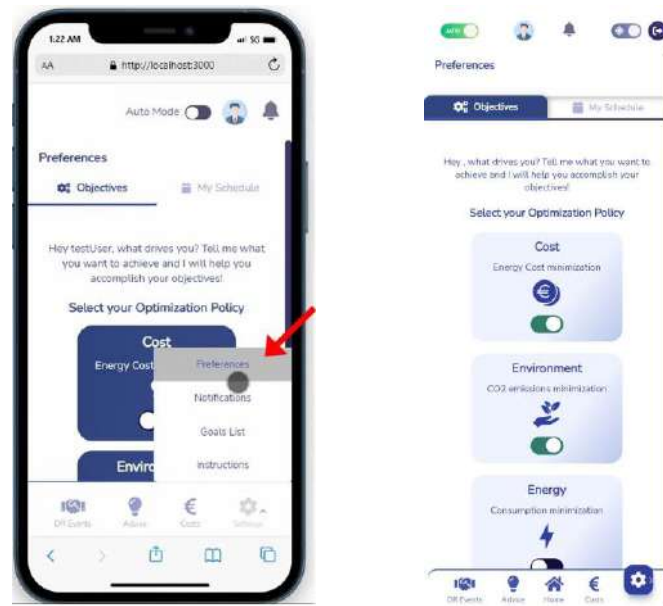


Figure 32: Web app – "My Objectives" screen

By clicking on the right tab of the "Preferences" page, namely "My Schedules", the users can add, edit, delete, activate or deactivate operation modes according to their wishes, as described in Figure 33.

The functionality of this page is elaborated in the current section, as it differs from the respective one in the mobile app, due to the different assets considered in each pilot. On this page, the users can find all the schedules they have set. Furthermore, towards 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 asset 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 the button "Add new Schedule" which is going to lead them to a form. Users must give a title for the new operation and define the days for the specific operation. Next, the users must select an asset from a list and give specific details about the desired operation of the asset and the specific hours. There is also a check box asking the users if they want to make the operation flexible. When the users choose to make the operation of an asset flexible, the time fields do not represent the exact hours that the asset will operate. Instead, they represent 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. When all the fields are filled, users select "Save" and the operation mode is saved and activated.

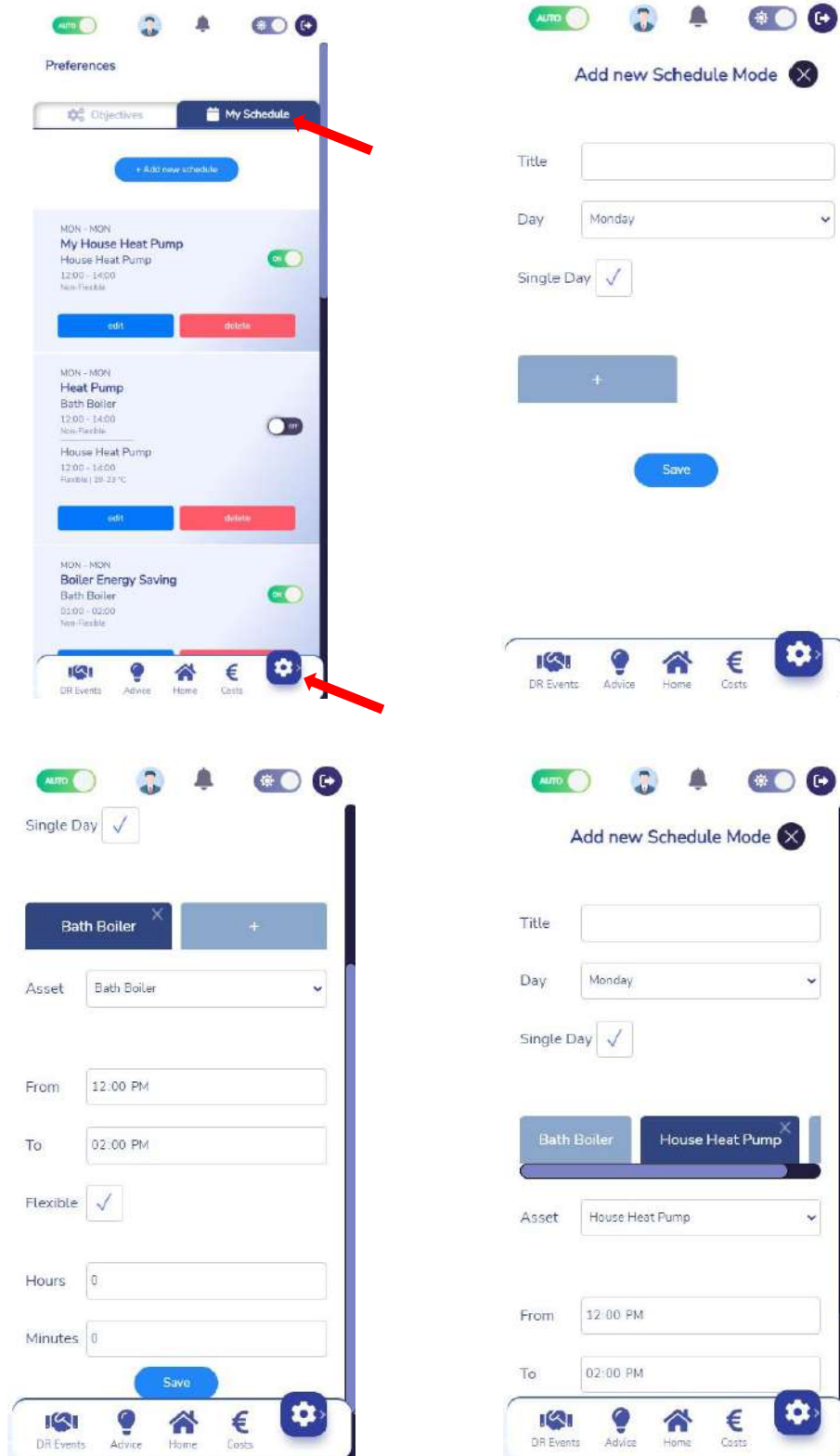


Figure 33: Web app – “My Schedules” screens

Upon selecting “Settings” and then “Notifications”, the iFA end users can add, edit, delete, activate or deactivate silence rules, so that they do not receive push notifications during their selected time periods. The relevant UI design is exposed in Figure 34.

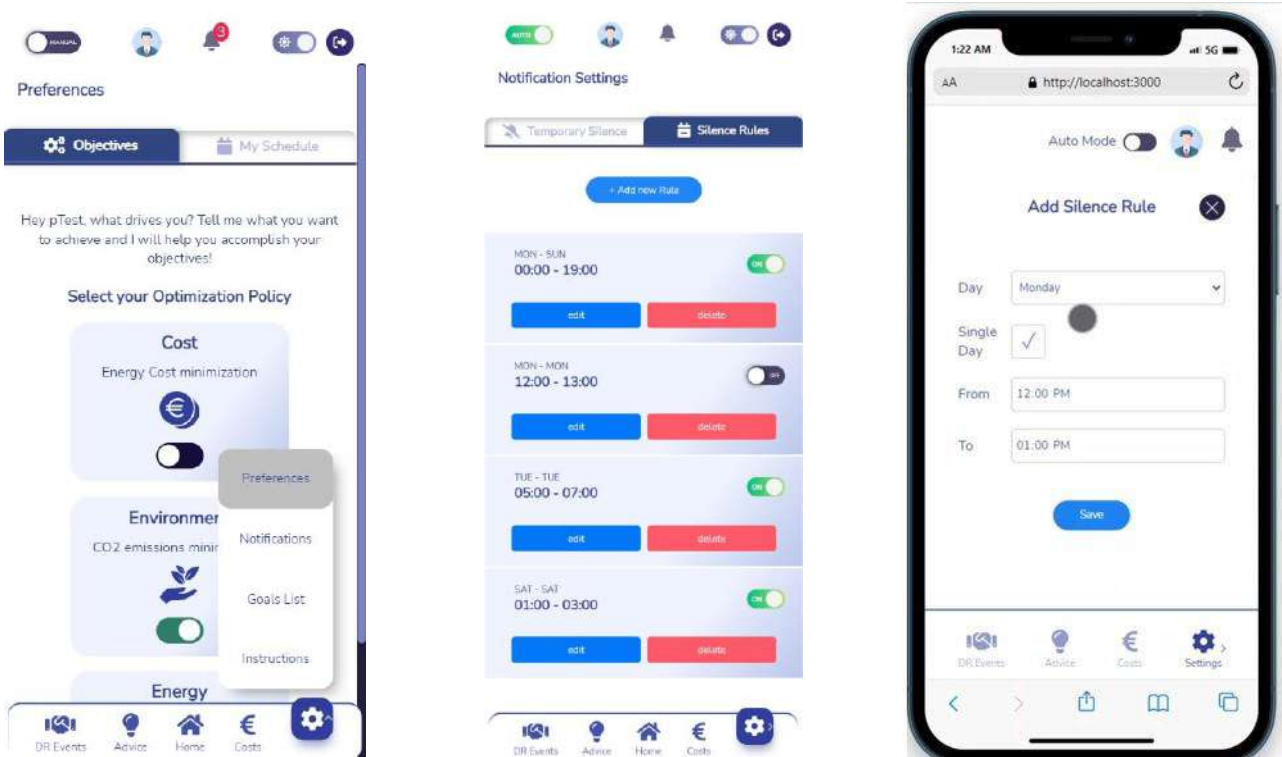


Figure 34: Web app – “Silence Rules” screens

If the users click on the right tab of the “Notification Settings” page, they access the “Temporary Silence” page, which enables them to temporarily pause push notifications for the time period of their choice. The relevant procedure is shown in Figure 35.

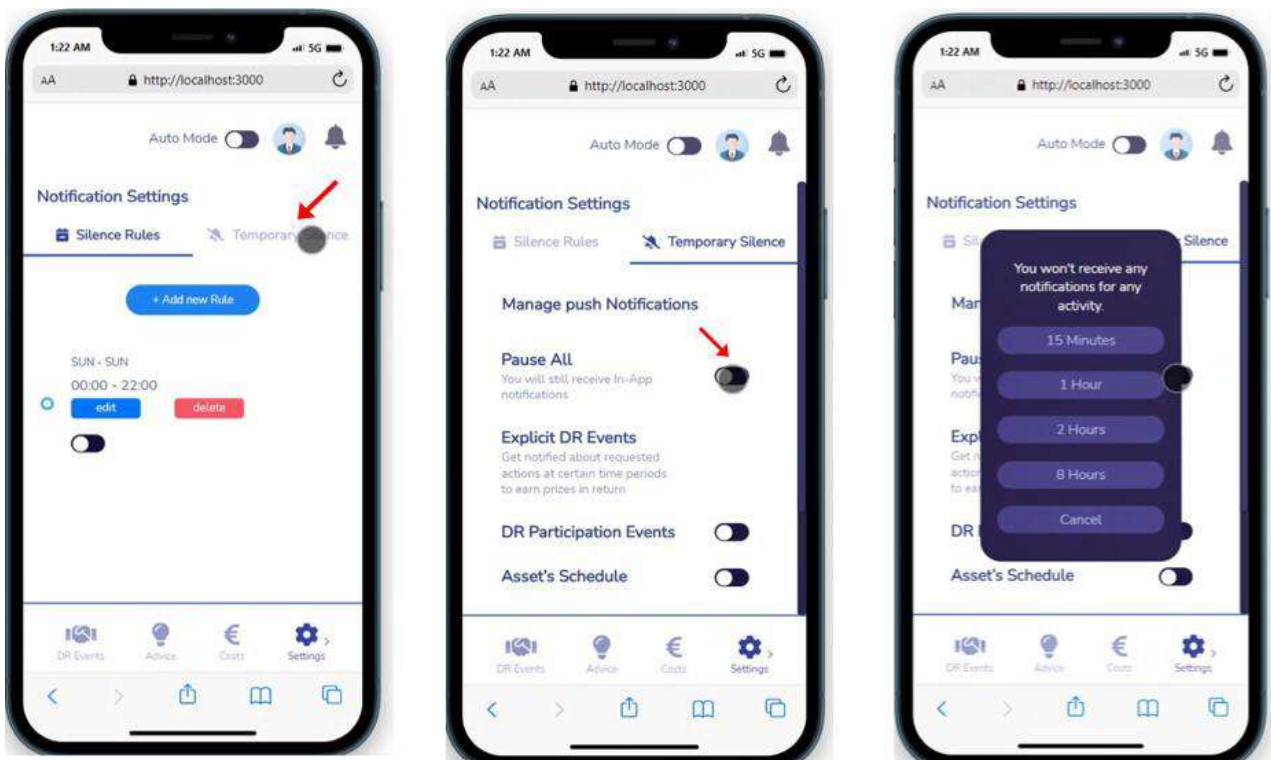


Figure 35: Web app – “Temporary Silence” screens

3.4.2.4 DR Participation

The iFA end users are also able to access their DR participation history, including both accepted and rejected DR events, by selecting “DR Events” at the bottom left of the screen. Examples of the relevant screens are shown in Figure 36.

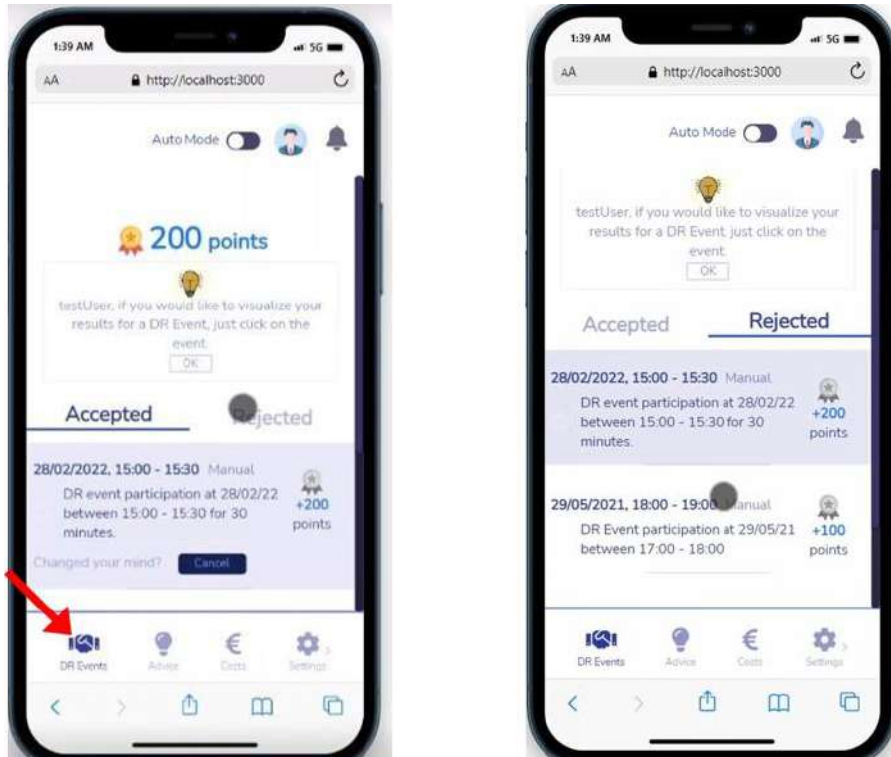


Figure 36: Web app – “DR Events” screens

3.4.2.5 Costs

By selecting the fourth option, which is called “Costs”, in the main menu found at the lowest part of the screen, users are able to see key facts regarding the three features grouped under Costs (Figure 37). If the users want to dive deeper into one of these features, they can select the relevant “View more” button, which will direct them to the screen of their choice among “My Tariffs”, “Costs Estimation”, and “My Savings”.

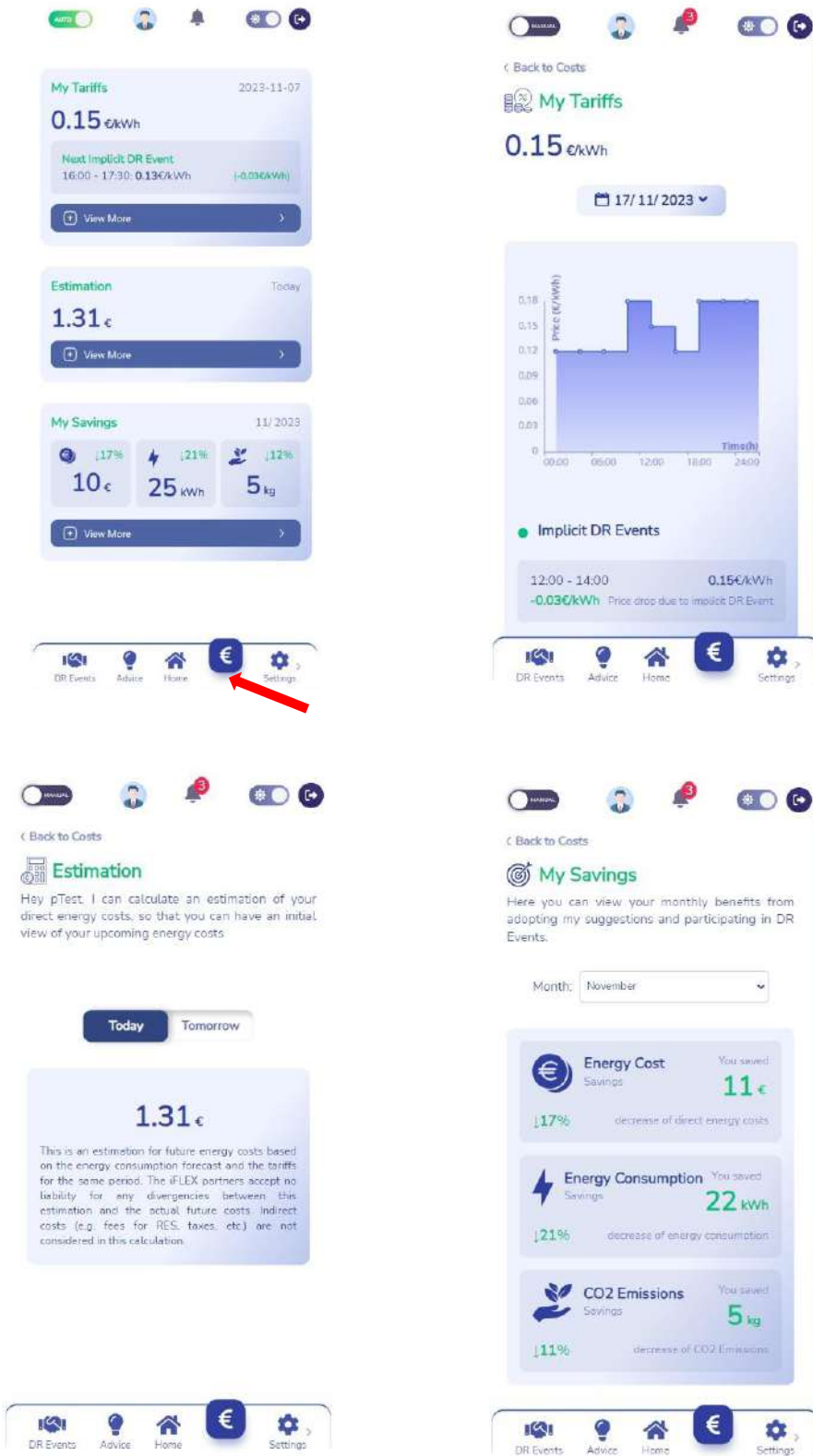


Figure 37: Web app – “Costs” screens

3.4.2.6 Advice

In the main menu, which can be found at the lowest part of the screen, users can access the “Advice” page by selecting the second option. In Figure 38, indicative energy advice concerning either asset operation or asset replacement is shown.

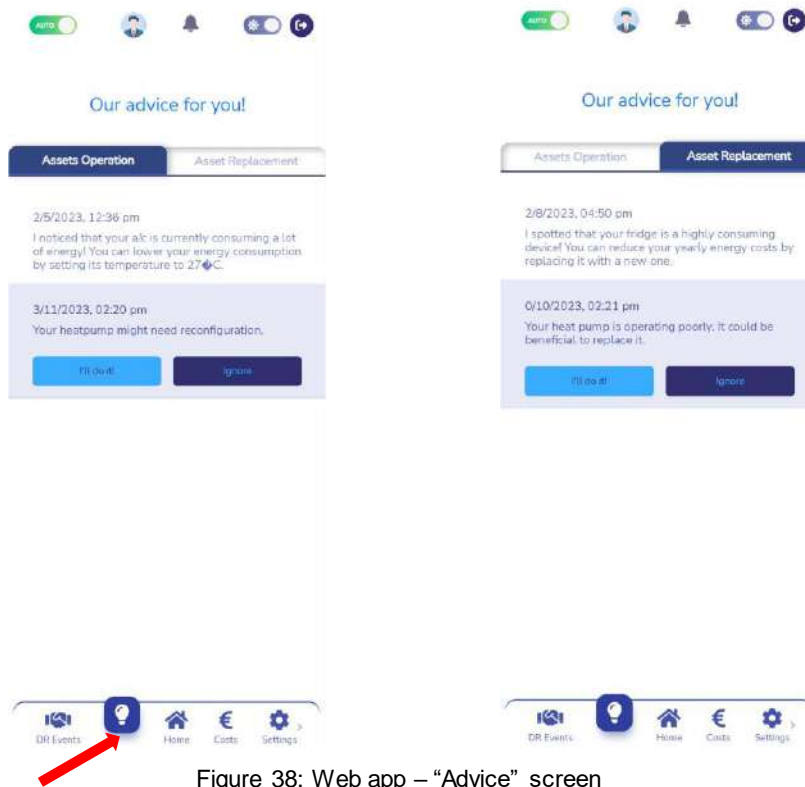


Figure 38: Web app – “Advice” screen

3.4.2.7 Auto Mode

The iFA end users can switch between auto and manual mode for their Assistant through the toggle button “Auto Mode”, which can be found at the top of the screen, as indicated in Figure 39.

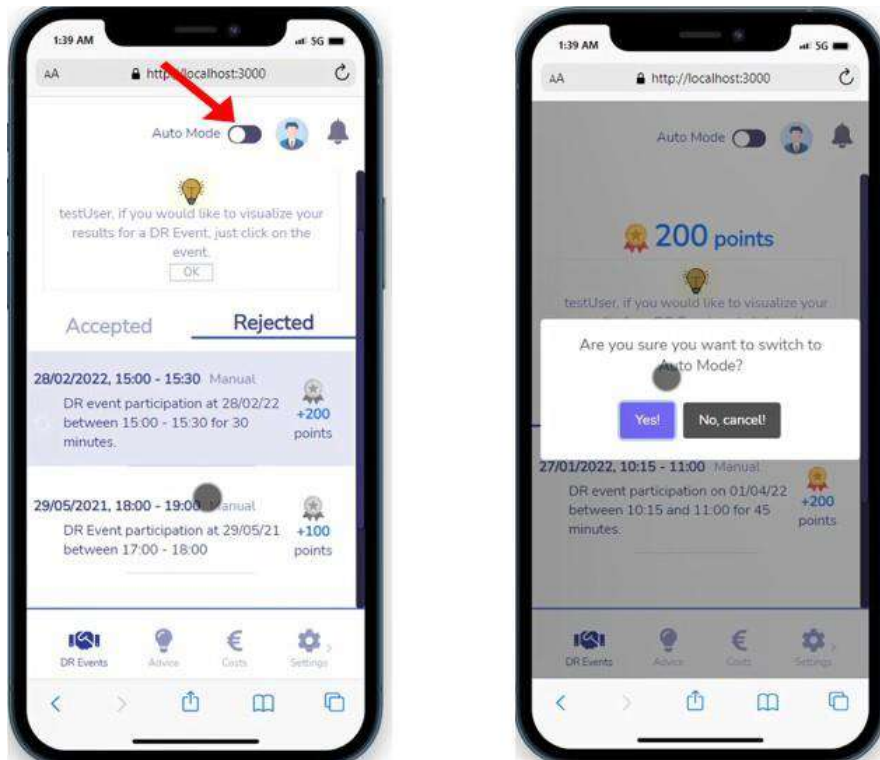


Figure 39: Web app – Activation of Auto Mode

3.4.2.8 Notifications

Users can access their notifications by clicking on the bell icon at the top of the screen, as shown in Figure 40. Filtering of notifications based on their category is also supported in the web app.

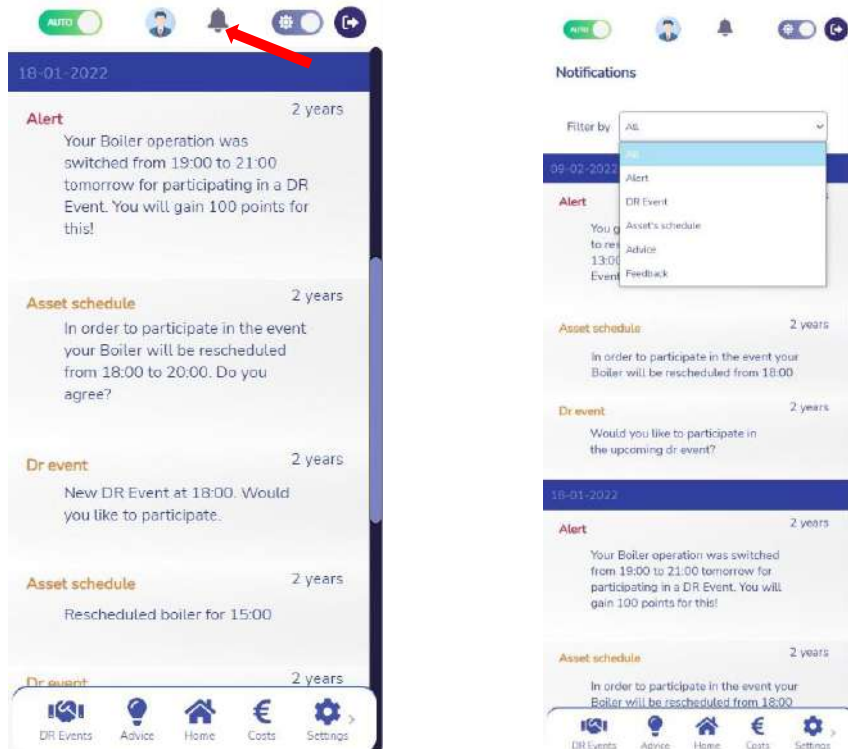


Figure 40: Web app – “Notifications” screens

3.4.3 Building community

3.4.3.1 Resident Interface

The Finnish pilot's UI displays information about building data to all residents, also to unauthenticated users. If you are a registered user and have sensors in your apartment, you can log in and see apartment temperature, humidity and CO₂ levels for different periods of time. All residents can give feedback about building temperature and registered users can give additional feedback about apartment temperature. Free text feedback can also be given. The navigation map illustrates navigation paths (Figure 41), whereas more detailed screenshots can be found below.

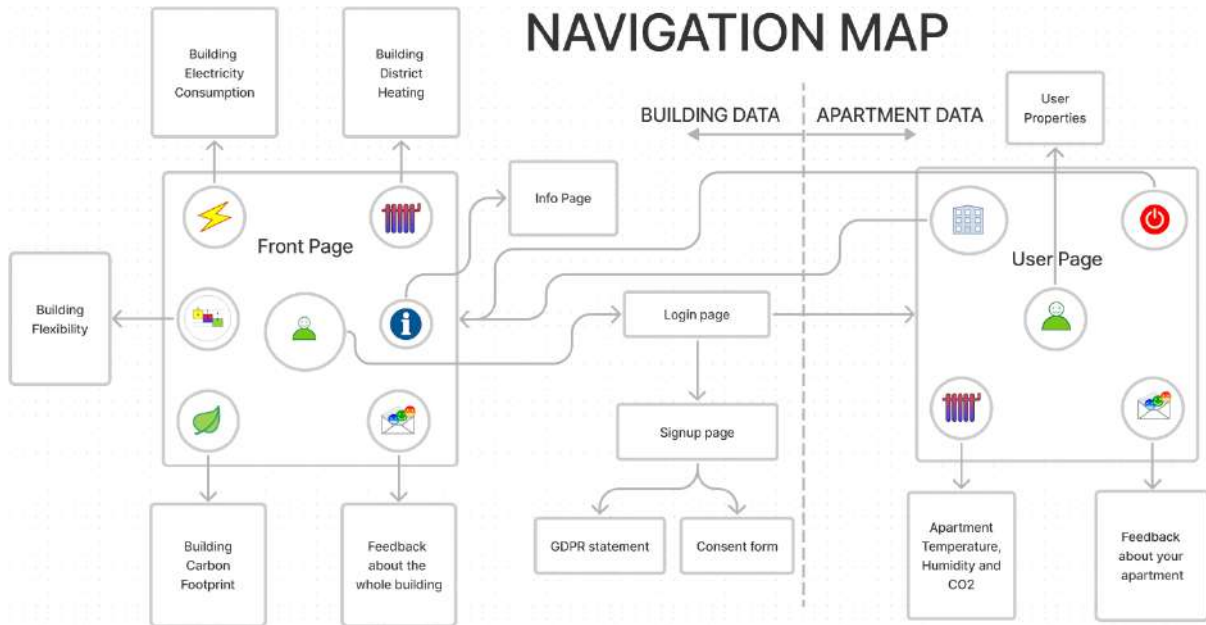


Figure 41: The navigation map of user interface

The main front page displays buttons to access building information: top left button opens building electricity consumption page, and top right button opens building district heating page (Figure 42). The time range for displayed measurement values can be selected using six predefined time range buttons on top of the chart: one day, one week, two weeks, one month, six months and thirteen months.



Figure 42: The Front Page: Building Electricity and District Heating

Bottom left button (the leaf) opens a display of the building’s CO₂ carbon footprint (Figure 43). It is calculated as a sum of electricity and district heating emissions from the building. The upper chart displays values per resident, where building values are divided by number of residents. The lower chart displays total emissions of the building at any given time. A small info-button opens the info page, where a short description about the iFLEX user interface is shown. The button on the bottom right opens a feedback page (Figure 43), where the user can send feedback about building temperature using 7-scale emoji-icons. The scale goes from: “Cold”, “Cool”, “Slightly Cool”, “Happy”, “Slightly Warm”, “Warm” to “Hot”. Additional free text input can be entered and if the feedback is about some specific date and time (for example: last Sunday in the morning it was too cold), there is a separate timestamp which can be adjusted from calendar and time components.

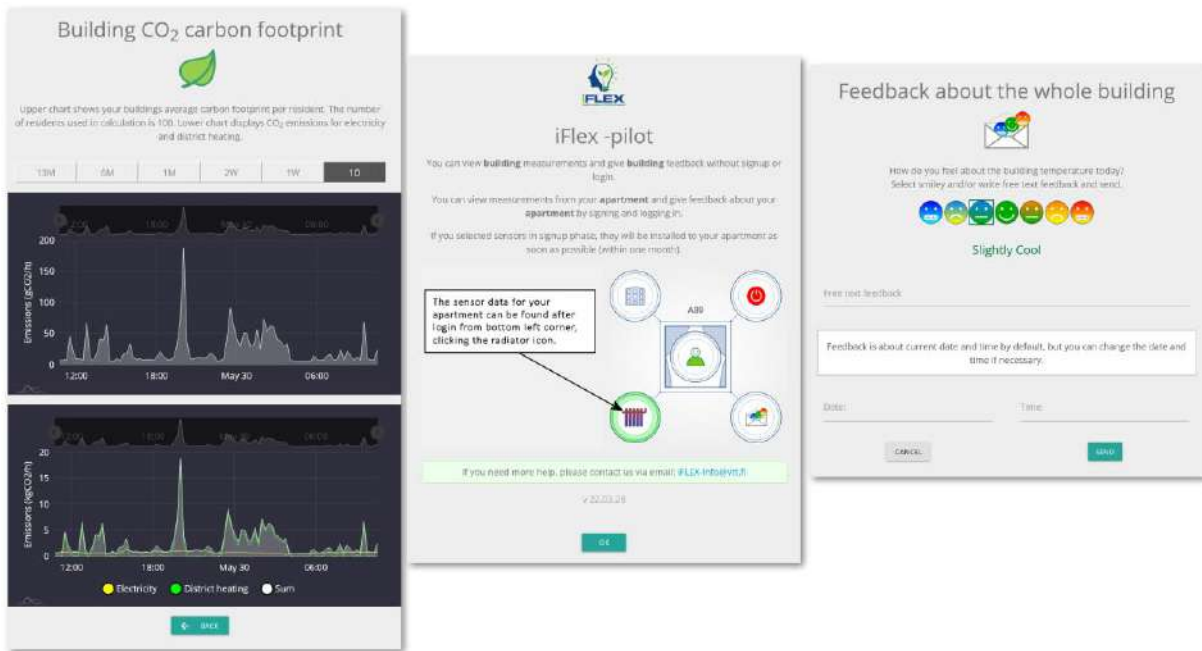


Figure 43: The Front Page: Building CO₂ Emissions, Info and Feedback

Residents of the Finnish pilot building can register via a sign-up process, where residents enter email, password, and apartment number and give consent to the iFLEX consortium, so that their data can be used for research purposes during the pilot (Figure 44). During sign-up, users can check the “Yes, I want sensors” checkbox, and have sensors installed in their apartment. The sensors measure temperature, humidity and CO₂ values.

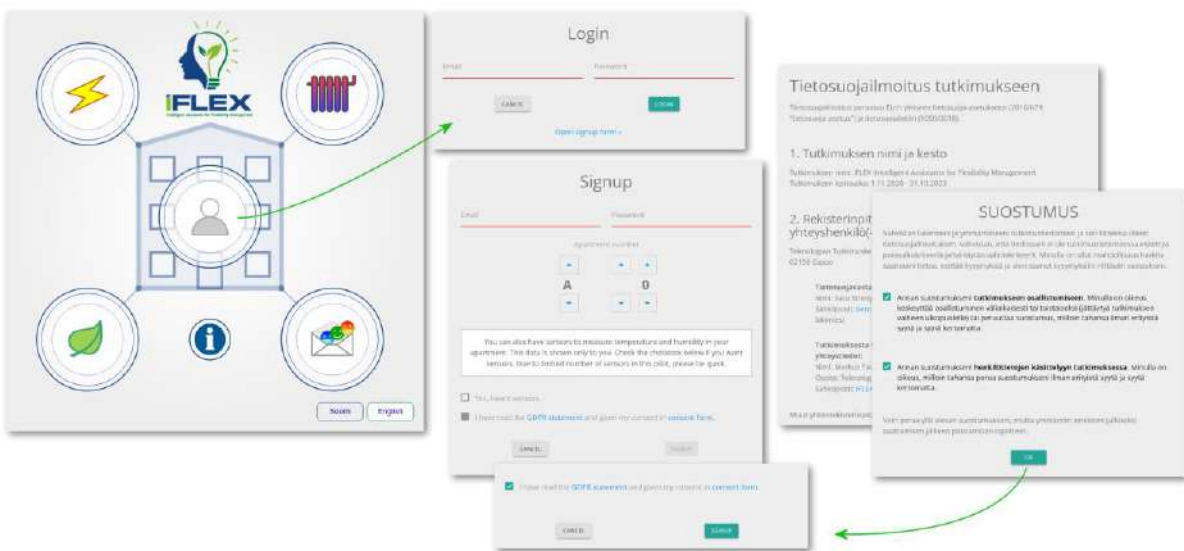


Figure 44: The Front Page: Log-in, Signup, GDPR and Consent

When the users have signed up, they can log in and enter the user page (Figure 45). There the users can view the apartment temperature, humidity and CO₂ values by selecting amongst the same six predefined time ranges, as in the building case previously. Buttons are on top of the chart: one day, one week, two weeks, one month, six months and thirteen months. The button on the bottom right opens a feedback page where users can send feedback about apartment temperature and give free text feedback, as in the previously presented building case.

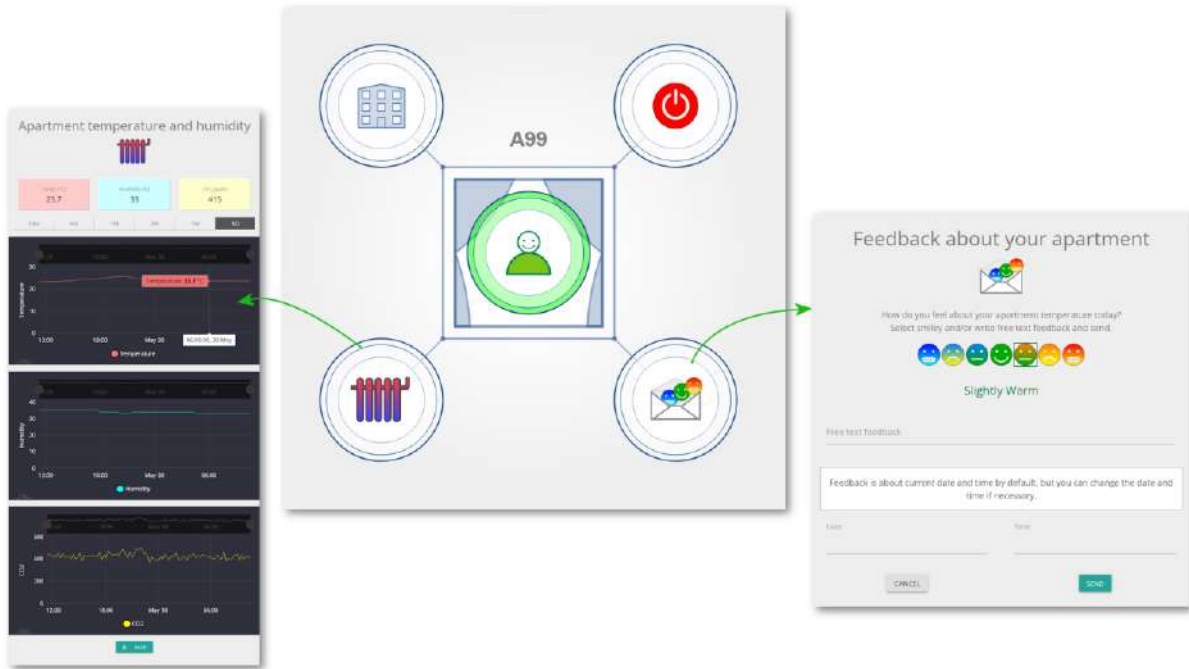


Figure 45: The User Page: Apartment Temperature and Feedback

The user button opens the “User Properties” page (Figure 46) where users can view the consent form and GDPR statement documents. If users want to change their password, it can be done here. The upper right button logs the user out and takes the user back to the front page. The upper left button also takes the user back to the front page without logging the user out.

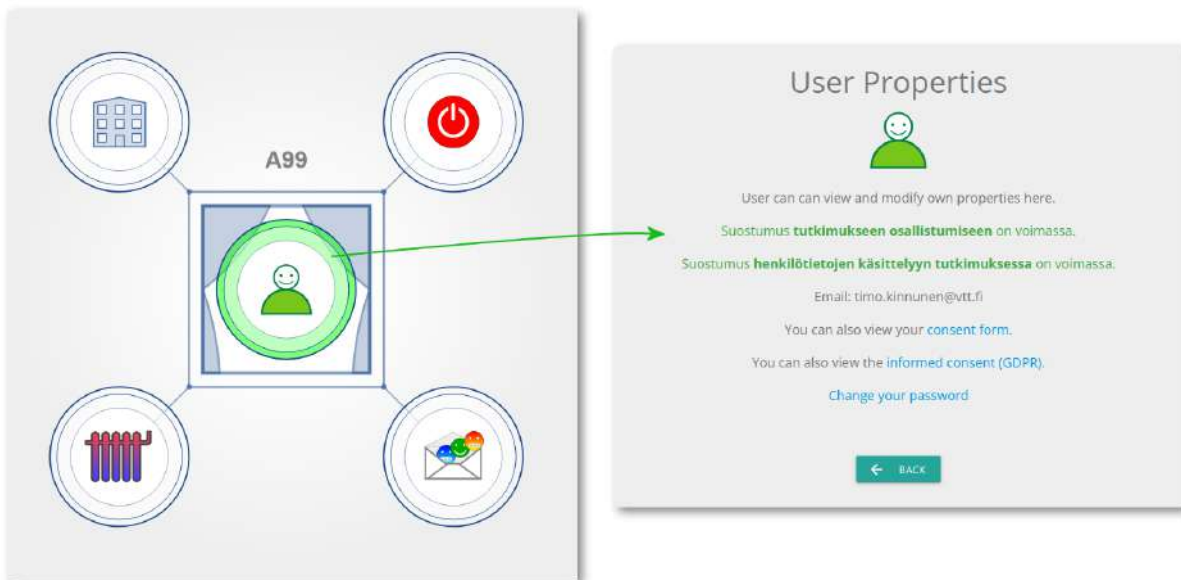


Figure 46: The User Page: User Properties

The front page displays savings for predefined time period. The user can set how many days is included in savings calculation (30, 60 or 90 days). Savings are calculated separately for energy cost, energy consumption and CO2 emissions. Front page shows decrease or increase percentage during selected timespan. By clicking “flexibility”-button user can view more detailed barcharts for electricity and district heating shares of savings (see Figure 47). The savings are calculated by comparing days when flexibility control is utilized to days when no control is used. The number of days (base / controlled) is set to be same in calculation.



Figure 47: The Front Page: Building Savings and Flexibility

3.4.3.2 Facility Manager Interface

The Facility Manager Interface is depicted in Figure 48. It is designed for engineers monitoring the building. The current implementation consists of four main views: electricity power, district heating power, heating system and room temperatures. Electricity power and district heating power views display the respective power loads in 1-minute resolution. A variety of heating water temperatures from different parts of the heating system are represented in the heating system view. The room temperature view displays the room temperatures from apartments registered for the pilot. Additional measurements exposed through the Facility Manager Interface are shown in Figure 49.

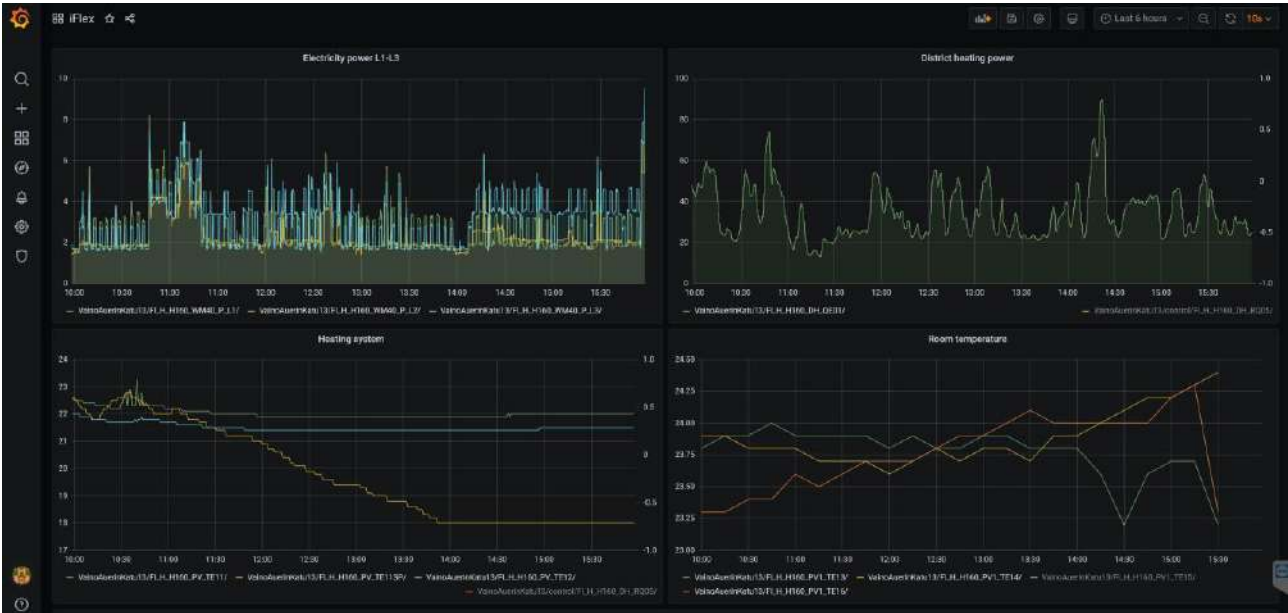


Figure 48: Facility Manager Interface designed for the Finnish pilot



Figure 49: Facility Manager Interface, additional measurements

4 Conclusions

This document aims to guide the development process with respect to the UI component in the final phase, and to serve as the primary documentation for the work done in the iFLEX project regarding the User Interfaces.

The design of the UI component was based on the use cases, requirements, and system architecture, as documented in previous deliverables. This report concludes the work on T3.3 – Natural User Interfaces, by providing the reader with the complete documentation, including work presented in the preceding deliverables of this task, namely D3.4 and D3.5. Moreover, the UI-related co-creation activities with end users throughout the iFLEX project are reported. These activities assist in the process of redesigning the UI, as well as adding new features to it.

The already developed functionalities of the UI solutions are reported, as well as the features that should be supported by the end of the project. Furthermore, the design of the UI component is analysed via three architectural views:

- Context view, presenting the interactions of the component with its environment at a high level;
- Functional view, focusing on the functionalities of the various sub-components of the UI;
- Implementation view, documenting the technology stack for the instantiations of the UI component per pilot.

The most up-to-date UI design is presented by exposing the applications, which have been developed for the three iFLEX pilots.

The UI is a critical component for systems such as iFA, as it enables the interaction of end users with such systems. In the iFLEX project, the focus is on developing User Interfaces that can be customised according to the user preferences, and provide the users with valuable insights regarding the energy and flexibility management of their premises. The efficiency of the UI in these tasks is deemed to be highly important for the acceptance and engagement of its end users.

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7 Appendix / Annex

7.1 Requirements documentation

The UI-related requirements are elaborated in this section. The abbreviations relevant to the columns on “Implementation” are clarified as follows:

- Not Applicable (N/A): This requirement is definitely considered as out-of-scope for this pilot.

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	N/A	1 st Phase	1 st Phase
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 (e.g. temperature limits) 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	N/A	1 st Phase	1 st Phase
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	VTT (FIN) ICOM (GR, SLO)	Low	1 st Phase	2 nd Phase	2 nd Phase

<i>FN-UI-04</i>	Optimisation policy selection	As an end user I want to be able to define the system's optimisation policy, so that it conforms to my motives (e.g. cost, energy efficiency, environmental).	PUC-1		ICOM	ICOM	Medium	N/A	1 st Phase	1 st Phase
<i>FN-UI-05</i>	Automation level customisation	As an end user I want to be able to opt for a desired automation mode and activate it, so that I can choose the level of automation of iFLEX Assistant's operation whenever I want.	PUC-1	FN-UI-01, FN-UI-02	ICOM	ICOM	High	N/A	1 st Phase	1 st Phase
<i>FN-UI-06</i>	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	-	Medium	N/A	N/A	N/A
<i>FN-UI-07</i>	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	ICOM & ECE (SLO)	High	N/A	N/A	2 nd Phase
<i>FN-UI-08</i>	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	PUC-9, PUC-10		ICOM	ICOM	High	N/A	1 st Phase	1 st Phase

		they comply with my will.								
<i>FN-UI-09</i>	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	ICOM	Medium	N/A	1 st Phase	1 st Phase
<i>FN-UI-10</i>	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	ICOM (GR, SLO) VTT (FIN)	Medium	1 st Phase	3 rd Phase	3 rd Phase
<i>FN-UI-11</i>	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	VTT (FIN) HERON (GR) ICOM (SLO)	High	1 st Phase	3 rd Phase	1 st Phase
<i>FN-UI-12</i>	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	VTT (FIN) HERON (GR) ICOM (SLO)	High	1 st Phase	3 rd Phase	1 st Phase
<i>FN-UI-13</i>	Flexibility reports	As an end user I want to receive flexibility reports, so that I can	PUC-4	FN-UI-22	ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase

<i>FN-UI-14</i>	Insights into energy efficiency	<p>have a more clear view with respect to my participation in explicit DR actions.</p> <p>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.</p>	PUC-7	FN-UI-15	ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase
<i>FN-UI-15</i>	Customised alerts	<p>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.</p>	PUC-1, PUC-7	FN-UI-10, FN-UI-14	ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase
<i>FN-UI-16</i>	Energy advising service	<p>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.</p>	PUC-1, PUC-5		ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase
<i>FN-UI-17</i>	Inspection of energy tariffs	<p>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-</p>	PUC-9, PUC-10		ICOM	ICOM	Medium	N/A	2 nd Phase	2 nd Phase

<i>FN-UI-18</i>	Available flexibility services	variant - energy tariffs and the ability to adapt my energy consumption accordingly. 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	-	Low	N/A	N/A	N/A
<i>FN-UI-19</i>	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	-	Low	N/A	N/A	N/A
<i>FN-UI-20</i>	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	-	Low	N/A	N/A	N/A
<i>FN-UI-21</i>	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	ICOM	High	N/A	1 st Phase	1 st Phase
<i>FN-UI-22</i>	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	PUC-4	FN-UI-13	ICOM	ICOM	Low	N/A	1 st Phase	1 st Phase

		participation in DR events.								
<i>FN-UI-23</i>	User Feedback on Satisfaction from DR Event	The users should be able to provide their feedback regarding their overall satisfaction from their participation in a DR event. This feedback takes into account multi-faceted incentives (e.g., rewards, peer pressure, etc.) provided to users for their participation to a DR event and their relation to the user discomfort, to determine a positive, a neutral or a negative perception on the DR event. This perception influences the probability that the user will participate in future DR events. This feedback may be visualised with 5-star Likert scale. <u>Rationale:</u> Allow the users to reflect on their overall satisfaction from DR events.	D5.2		AUEB	-	Medium	N/A	N/A	N/A
<i>FN-UI-24</i>	UI for user standing with respect to DR performance as compared to others	Visualise relative user performance in DR events. E.g., a tree image in a forest, where the size and the greenness of the tree represent high DR	D5.2		AUEB	-	Medium	N/A	N/A	N/A

		<p>performance. Negative/aggressive visualisation should be precluded. <u>Rationale:</u> Exercise peer pressure to the user with visualisation of comparative standing with respect to DR performance as related to other users.</p>								
<p><i>FN-UI-25</i></p>	<p>UI for user standing with respect to participation as compared to others</p>	<p>Visualise relative user participation rate to DR events. E.g., a tree image in a forest, where the size and the greenness of the tree represent high DR participation rate. Negative/aggressive visualisation should be precluded. <u>Rationale:</u> Exercise peer pressure to the user with visualisation of comparative standing with respect to DR participation as related to other users.</p>	<p>D5.2</p>		<p>AUEB</p>	<p>-</p>	<p>Medium</p>	<p>N/A</p>	<p>N/A</p>	<p>N/A</p>
<p><i>FN-UI-26</i></p>	<p>View asset schedules when offline</p>	<p>As an end user I would like to see the schedules of my assets in my mobile application even when offline, so that I can have a clear view of them at all times – regardless of internet connectivity.</p>	<p>Greek pilot discussions on iFA</p>		<p>ICOM</p>	<p>ICOM & HERON (GR)</p>	<p>Medium</p>	<p>N/A</p>	<p>3rd Phase</p>	<p>N/A</p>

<i>FN-UI-27</i>	Actual schedules of assets	As an end user I would like to see the schedules of my assets, so that I can have a clear view of the schedules that are actually followed (and not only my schedule preferences).	Greek pilot discussions on iFA		ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase
<i>FN-UI-28</i>	Estimation of energy costs	As an end user I want to view an estimation of my energy costs, so that I can have an initial view of my upcoming energy costs for predefined periods.	D2.4		ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase
<i>FN-UI-29</i>	Benefits from iFA's operation	As an end user I want to view an estimation of the benefits (e.g., savings in Euros, savings in CO ₂ emissions, increase in self-consumed energy in kWh) from adopting iFA's suggestions, so that I can actually see what iFA offers to me.	D2.4		ICOM	ICOM	Medium	N/A	3 rd Phase	3 rd Phase
<i>NF-UI-01</i>	The iFA UI of the Greek pilot should be integrated in the existing Mobile App	HERON has an existing app that will be used by its customers for participation in Smart Grid projects. The app should easily integrate iFA functionalities for iFLEX project participants. <u>Rationale:</u> Increased user experience. Interoperability.	Greek pilot discussions on iFA		ICOM	ICOM & HERON (GR)	High	N/A	3 rd Phase	N/A

NF-UI-02	Easy onboarding in iFA usage	As an end user, I would like a wizard/questionnaire to guide me and create my profile and automatically fill some settings (which can be later edited) upon my first log-in to the mobile application, so that I don't have to fill too much information myself.	Workshop between Slovenian partners and ICOM (as UI provider)	ICOM	-	Medium	N/A	N/A	N/A
NF-UI-03	App walkthrough	As an end user, I would like to have access to an app walkthrough, so that it explains to me the functionality of each page of my app whenever I want.	Usability tests	ICOM	ICOM	Low	N/A	N/A	2 nd Phase

7.2 Functionalities of the UI module

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 [4] – 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 that were documented in the Appendix of D4.6 [26]. These SUCs concern communicating flexibility signals and energy tariffs to the pilot users via their Assistants. The reader is referred to D4.6 for more details. As regards the sequence diagrams presented in this section, the exchanged data between iFA's components comply with the iFLEX data model (see D2.5 – Final Architecture of iFLEX Framework [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)¹³ on sequence diagrams [27].

7.2.1 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 50.

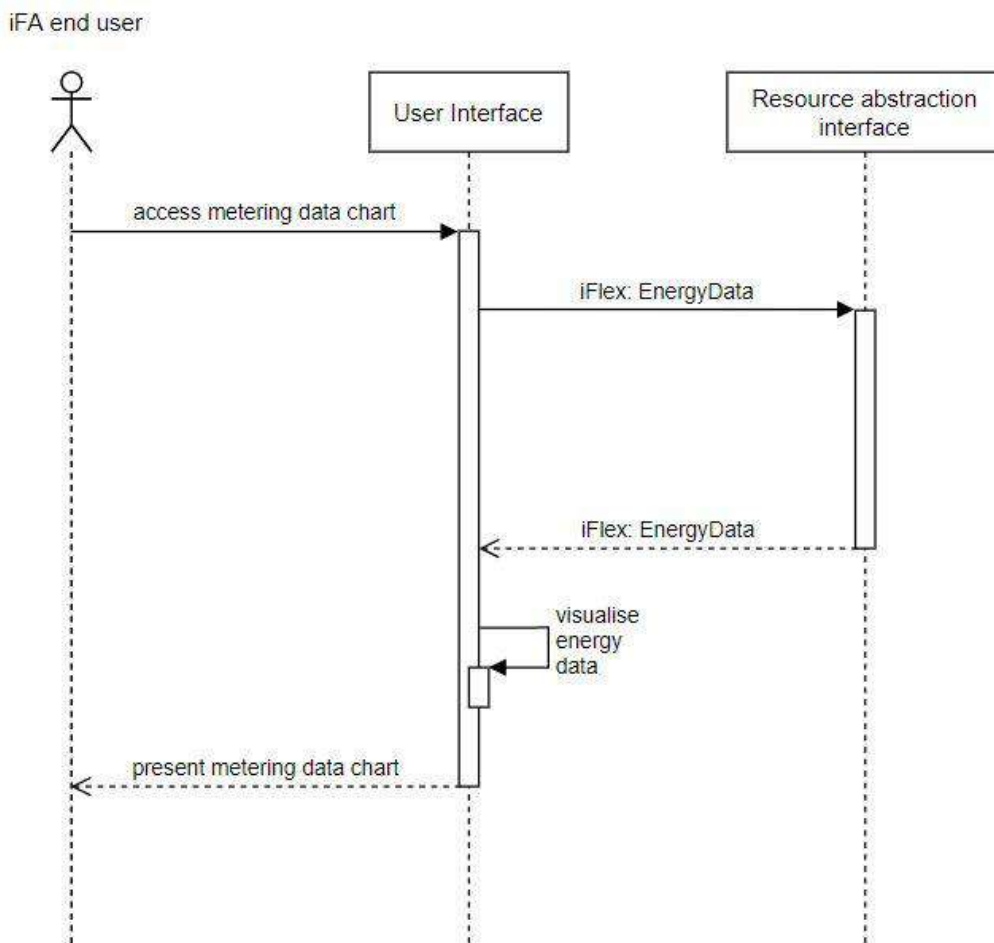


Figure 50: Sequence diagram of SUC-9 - Access real-time energy data

¹³ The Unified Modelling Language: <https://www.uml-diagrams.org/>

Table 1: 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

7.2.2 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 CO₂ 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 51.

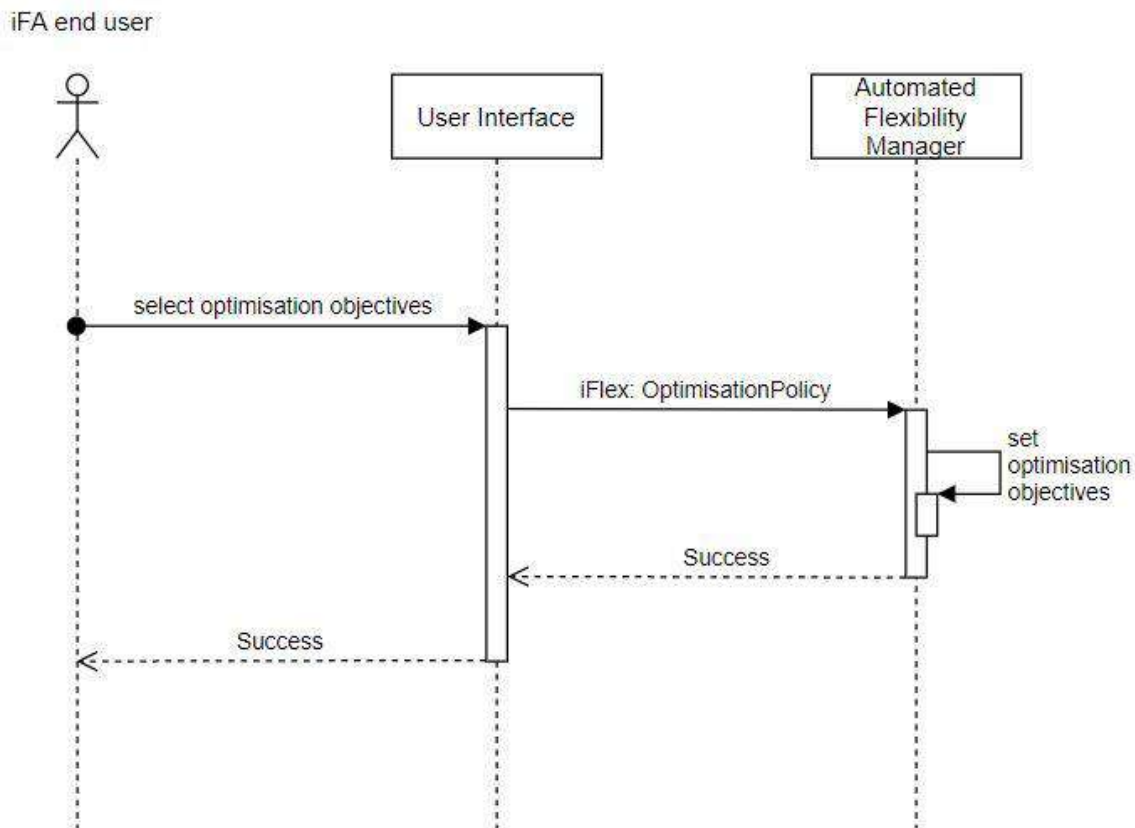


Figure 51: Sequence diagram of SUC-10 - Define optimisation policy

Table 2: 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

7.2.3 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 52.

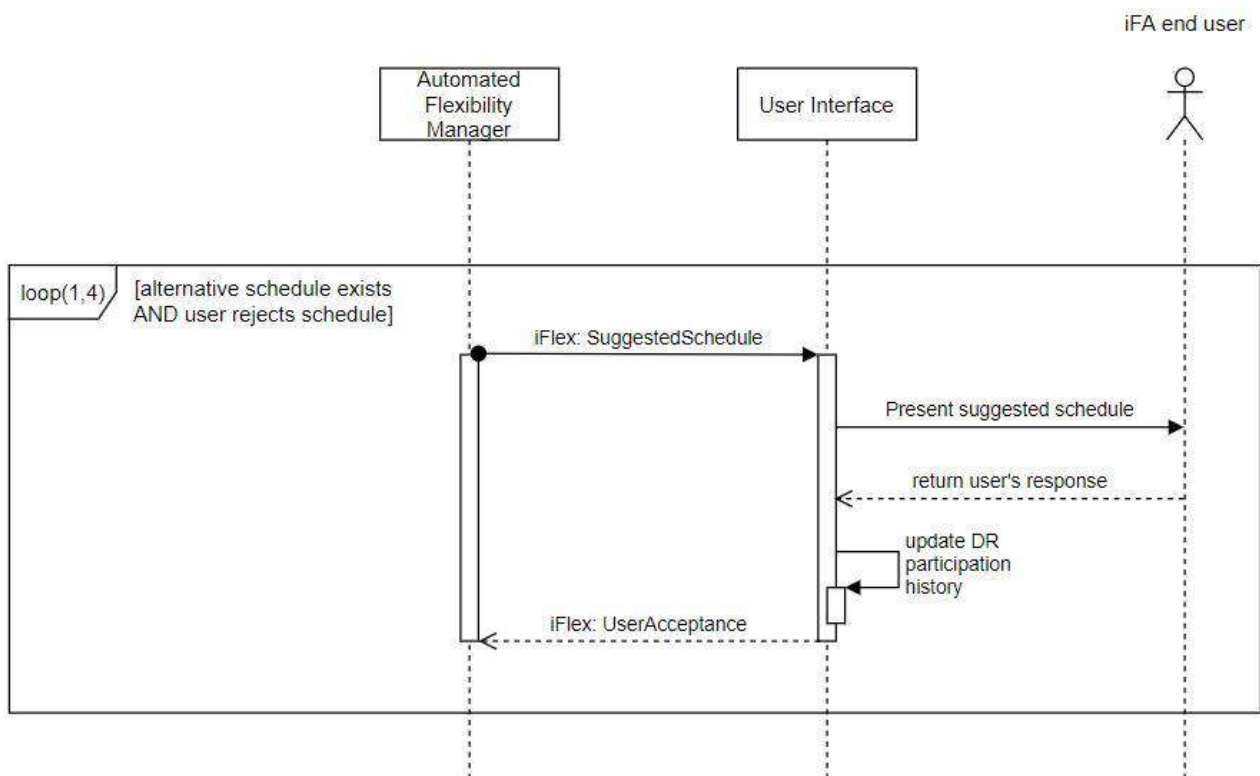


Figure 52: Sequence diagram of SUC-11 - Grant acceptance to schedules, Scenario: Manual operation

Table 3: 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

7.2.4 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 53.

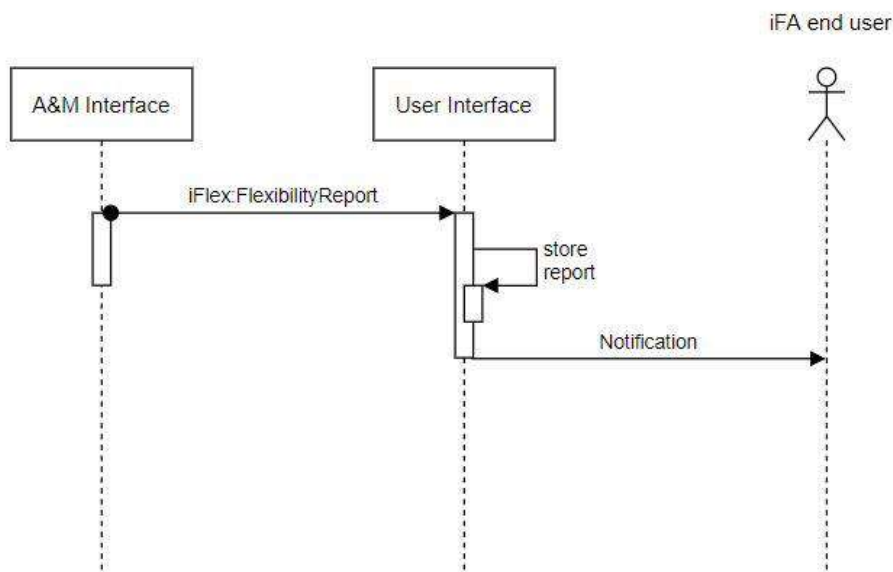


Figure 53: Sequence diagram of SUC-12 - Present reports, Scenario: Receive new flexibility report

Table 4: 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	<ol style="list-style-type: none"> 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

7.2.5 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 54.

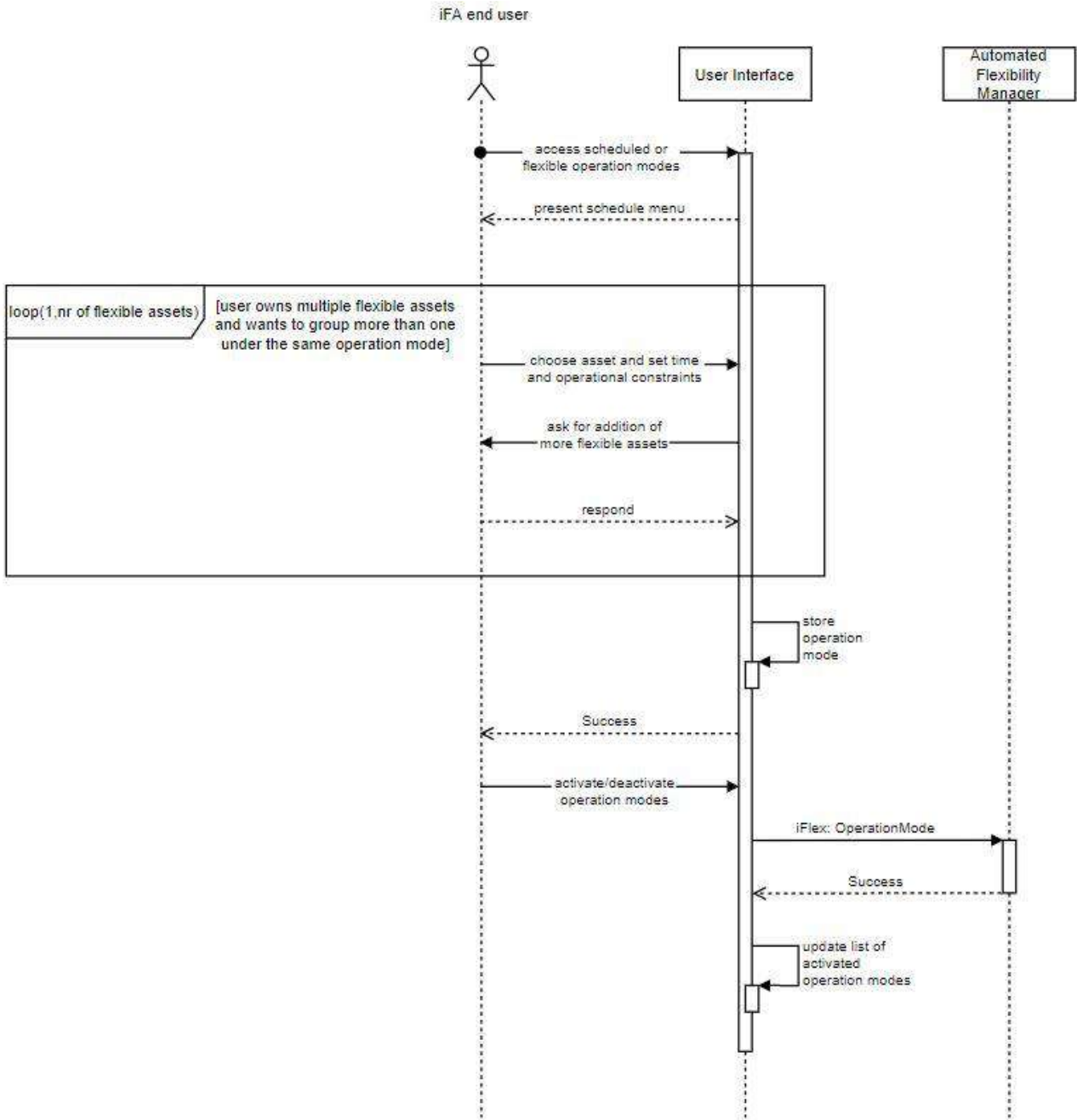


Figure 54: Sequence diagram of SUC-13 - Define comfort levels, Scenario: Set schedules of flexible assets

Table 5: 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

7.2.6 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 55 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.

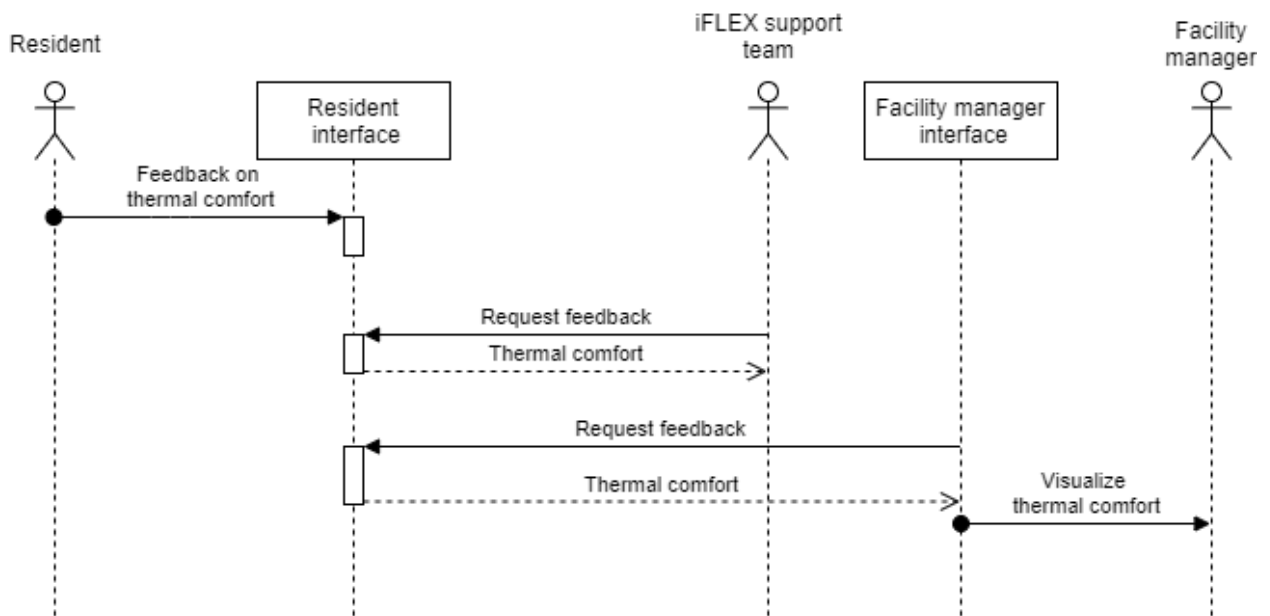


Figure 55: Sequence diagram of SUC-14 - Provide feedback on thermal comfort

Table 6: 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	<ol style="list-style-type: none"> 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