COLLECTiEF

CONCEPT OF THE COLLECTIEF HUMAN-BUILDING INTERFACE

Project acronym: COLLECTiEF

Project title: Collective Intelligence for Energy Flexibility

Call: H2020-LC-SC3-EE-2020-2

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Executive Summary

The main objective of this deliverable is to report the status of the COLLECTiEF user interface, which will allow users to interact with the COLLECTiF system. Specifically, the document provides the design methodology and principles followed to develop the COLLECTIEF user interface, the back- and font-end developments.

This report is structured as follows:

- **Chapter 1** provides a description of the related tasks and the scope of this report.
- **Chapter 2** gives an introduction and a background on the user interfaces, in particular to human-building interfaces.
- **Chapter 3** describes the concept and the procedure followed to develop the architecture of the COLLECTiEF user interface and its main functionalities. Moreover, describes in high-level the algorithms and to be deployed on the COLLECTiEF solution, the back-end and front-end components of the COLLECTiEF user interface.
- **Chapter 4** concludes this report.

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List of Acronyms

API	Application Programming Interface
AI	Artificial Intelligence
AR	Augmented Reality
ALD	ASHRAE Likelihood dissatisfaction
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AHU	Air Handling Unit
BRiG	Boarder Router Intelligent Gateway
BIM	Building Information Modeling
BMS	Building Management System
CSS	Cascading Style Sheets
CO2	Carbon Dioxide
CI	Collective Intelligence
D	Deliverable
DB	Database
DIMOSIM	District Modeller & Simulator
DSM	Demand Side Management
DHW	Domestic Hot Water
EN	European Norm
G2Elab	Grenoble Electrical Engineering Lab
GreEn-ER	Teaching and Research on Energy in Grenoble
HBC	Human-Building-Cluster
HTML	HyperText Markup Language
HVAC	Heating, Ventilation and Air-Conditioning
HW	Hardware
IEQ	Indoor Environmental Quality
IoT	Internet of Things
JSON	JavaScript Object Notation
JS	JavaScript
LPD	Long-term Percentage of Dissatisfied
KPI	Key Performance Indicator
MQTT	Message Queuing Telemetry Transport
OS	Operating System
POE	Post Occupancy Evaluation
Partner	The beneficiary in the COLLECTiEF Project
PM	Particulate Matter
RL	Reinforcement Learning
PV	Photovoltaic
SD	Secure Digital

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SRI	Smart Readiness Indicator
SW	Software
SSD	Solid-State Drive
SQL	Structured Query Language
TMY	Typical Meteorological Year
TVOC	Total Volatile Organic Compound
UDI	Useful Daylight Illuminance
URL	Uniform Resource Locator
UI	User Interface
UX	User experience
USB	Universal Serial Bus
WHO	World Health Organization
WP	Work Package

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1 Description of the task

This deliverable is an outcome of the T3.4 Development of the COLLECTiEF user interface. From the Grant Agreement:

"*In this task a user-friendly Human-Building interface will be developed by adapting and expanding the functionalities of the existing G2Elab app to (1) provide indication of the state of indoor environmental control devices, (2) inform occupant about the quality of the indoor environment, (3) suggest optimization strategies for optimal control of the environment and energy conservation, (4) notify alarm conditions, show historical data and compare current operation modes (e.g. setpoint temperature, lighting state) with the other users' current behaviour in the building, (5) collect users' feedback, override automatic controls to take manual control, and (6) provide cumulated reports on the indoor environmental quality and consumption trade-off over a given time period. The user-friendly Human-Building interface is incorporated into the IoT Operating System. Furthermore, Fully Integrated Dashboard will be developed to support interactive data management providing digital indicators, gauges, and diagrams to visualize information/knowledge. Virtual will collect requirements for the user-friendly Human-Building interface and enhance/adapt designed digital dashboards toward requirements of the Human-Building user interface. CyI will develop the concept of a user-friendly Human-Building interface integrated into the IoT Operating System. The current app for occupant information in the Green'ER small scale pilot can be used as a platform for inspiring the development of the user-friendly Human-Building interface (partner CSTB). The app will be presented by the third party G2Elab. CETMA will provide experience in the development of software platforms (performance evaluation dashboards) for sharing information, where the principles of usability and scalability of the system are respected. NTNU will provide further data on occupant behaviour in the educational buildings collected by sensors currently installed at NTNU campus.*"

1.1 Scope and purpose

This deliverable entitled "*Concept of the COLLECTiEF Human-Building interface*" aims to provide an overview of how the COLLECTiEF user-interface is designed following the principles of user-friendliness, simplicity, reusability, as-open-as-possible/as-closed-as-need, privacy, and security. Specifically, this deliverable describes the concept, functionalities, and architecture of the COLLECTiEF user-interface.

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2 Introduction

COLLECTiEF is a Horizon 2020 Innovation Action project that aims to improve the smartness of existing building with low-cost solutions. The consortium is enhancing, implementing, testing and evaluating an interoperable and scalable energy management system based on Collective intelligence (CI), which allows easy and seamless integration of legacy equipment into a collaborative network within and between existing buildings and urban energy systems with reduced installation cost, data transfer and computational power while increasing data security, cluster energy flexibility, building climate resilience and user satisfaction. This is done through developing software packages and hardware solutions to install and smart up buildings and their legacy equipment on large scale, meanwhile to maintain simple and robust communication with the local energy grid.

One of the fundamental components of the COLLECTiEF solution, is the user interface that aims to ease the interaction between humans and physical infrastructure i.e., devices, buildings, computational nodes. COLLECTiEF user-interface is in the development phase, and is being customized based on user profiles (end-user, facility manager, cluster manager) and level of operation (i.e., room, apartment, building, and building network) to provide differentiated data access level and graphical data visualization options.

To enhance communication, we provide clear definitions of the terms that are used in the following document.

- ***User interface*** or ***human-machine interface*** corresponds to the means by which the user and a computer system interact, in particular, the use of input devices and related and enabling software.
- ***Software/digital platform*** is an environment in which a piece of software is executed. It may be the hardware or the operating system, even a web browser and associated application programming interface, or other underlying software, as long as the program code is executed with it.
- ***Software application (App)*** is a computer program designed to carry out a specific task other than one relating to the operation of the computer itself, typically to be used by end-users.
- ***Dashboard***, in computer information systems, is a type of graphical user interface that often provides at-a-glance views of given key performance indicators (KPIs) relevant to a particular objective or task.
- ***Internet of Things (IoT)*** describes physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.
- ***Operating System (OS)*** is a software-based control panel for managing multiple applications, network devices, or industrial machines.
- ***Front-end*** is the presentation layer, it’s that part of an application that the user can interact with, for example by entering input data or specifying setting, and visualize data and KPIs.
- ***Back-end*** refers to the server-side components and processes that power and support the functionality and data management of a software application and that cannot be accessed by a user.
- ***Edge Node*** corresponds to both hardware and software components that act at the building level.

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- ***Cluster Node*** corresponds to both hardware and software components that act at the level of buildings' network.
- ***Fully-integrated Dashboard*** refers to the dashboard that is implemented at the Cluster Node, and it coordinates a network of buildings for increasing energy flexibility and climate resilience.
- ***Human-building interface*** is the user interface between humans and buildings that will be implemented at the Edge Node and interacts will occupants and building systems in order to address the requests for energy flexibility and, at the same time, optimize occupants' satisfaction.
- ***Human-Building-Cluster (HBC) interface*** refers to the dashboard that is implemented at both the Cluster and Edge Nodes. It coordinates a network of buildings for increasing energy flexibility and climate resilience and enables the interaction between occupants and building systems in order to (1) provide energy saving, (2) address the requests for energy flexibility (3) enhance occupant satisfaction, and (4) provide a healthier indoor environment.

The following sections present a brief background on of HBC interface, current practices, and some use cases of the human-building interface currently operating at the French pilot building, i.e., G2Elab.

2.1 Background on human-building interfaces

Considering that humans spend over 90% of their time indoors [1], despite how well a building may be designed, the way it is used by its occupants remains a determinant of its energy consumption footprint [2]–[4]. Human-building interaction lies within the study and design of interactive opportunities for building occupants to shape the physical, spatial, and social state of their built environments [5][6]. Allowing occupants to alter conditions within the building allows them to reach and sustain a desirable level of comfort, whether that is thermal, acoustic, or visual, setting the grounds for improved well-being and productivity [7], [8]. Although in the past, the focus has been placed on increasing the energy efficiency of buildings through technology, it has been observed that energy savings are achievable if building occupants have a higher level of awareness and adapt their actions accordingly [5]. Higher comfort is often related to higher energy consumption; however, a simulation-based multi-objective optimization study has shown that up to 60% of annual heating, ventilation, and air-conditioning (HVAC) energy can be saved if set point temperatures are optimized without compromising the thermal comfort perceived by the building users. This study highlights that an essential step towards more sustainable and user-centric built environments is investigating in more depth building-occupant interactions to gain a better understanding of the dynamics guiding occupant behaviour [9].

A diverse array of approaches is found in occupant-centered control systems which should be adjusted according to a system's potential for energy savings [10], [11]. For instance, a gamification approach has been proposed to act a framework facilitating humans-in-the-loop modelling, where building managers are able to interact with occupants through an interface, with the possibility to reward energy-efficient attitudes [12]. Graphical user interface are suitable mediums that enable communication between occupants, owners and service providers, and again, selecting the appropriate degree of detail seems to be instrumental in user engagement. For instance, it has been found that three-dimensional visualisation is not as valuable to users as advanced services such as monitoring occupancy and space reservations [13]. Research on human-building interface is now

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becoming anthropocentric and is informing and shaping HVAC practice, focusing on the concrete implications of control systems and the feedback available to users and modellers alike [14]–[17].

2.2 State-of-practice of user-building interfaces

Human-Building Interaction explores the development and application of computer technology in connection to the constructed surroundings, emphasizing the connections between humans and computers, as well as the interplay between individuals and their environment [18]. State-of-the-art Human-Building Interface design is characterised by the integration of a wide range of functionalities and technologies that facilitate better interaction between the user and the building and its devices. With the aim of developing an intuitive, multimodal, customisable and accessible Human-Building Interface design, focus is spot on the user experience and on the rising opportunities offered by the integration of emerging technologies (e.g., IoT, AI) [18], [19].

Special attention is also paid to usability, scalability, accessibility and information security, promoting intelligent and interconnected solutions to ensure the best possible user experience improving occupant comfort and to reduce the environmental impact of buildings [20]–[23]. These systems are referred as cyber-physical systems or embedded systems.

Usability: Interfaces should be easy to understand, learn and use, with a clear and consistent structure that offers easy navigation and intuitive functionality. Best practices include keeping the interface simple, creating consistency, being purposeful in page layout, using colour and texture strategically, using typography to create hierarchy and clarity, and making sure that the system communicates what's happening [20]–[22].

Scalability: Interfaces must be able to adapt to different user profiles, levels of operation and varying numbers of buildings and networks, handling increasing amounts of data and additional functionality without compromising overall system performance [18], [23].

Customisation: Interfaces must allow users to customise the appearance, layout and functionality according to their individual preferences and needs, offering the possibility to create customised dashboards, graphs and diagrams, as well as set up customised notifications and schedules [22], [23]. This feature is implemented in the current HBC interface, however, template will be on purpose designed and provided to user groups and tested in the pilot buildings.

Accessibility: Interfaces should allow users (including those with disabilities or impairments) to interact with the building using a variety of methods, including voice commands, gestures, touchscreens and mobile applications. This flexibility allows for a personalised and accessible experience for all occupants [18], [22].

Security and privacy: Interfaces should prioritise security and privacy, ensuring that user data is protected, and only authorised users have access to sensitive information, implementing robust authentication mechanisms, encryption protocols and adhering to data protection regulations [18], [21], [23].

The design of the Human-Building-Cluster Interface follows a structured and methodical approach, consistent with best practices in the field of user interface design and human-computer interaction

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[24], [25], facilitating the interaction between users and the physical infrastructure of buildings. To design a Human-Building-Cluster Interface, the following steps are followed:

1. **Requirements analysis and user and building needs:** a successful interface design begins with a thorough requirements analysis, identifying and documenting the needs and expectations of all stakeholders involved in the project, ensuring that the system can meet their needs and offer an excellent user experience [20]. To achieve this, user research methods like interviews, surveys, and focus groups were employed to uncover occupant preferences, behaviours, and goals. Also, building energy use was studied through energy audits and leveraging data from sensors and meters to yield additional insights. Involving all stakeholders, such as building owners, facility managers, and occupants, ensures a comprehensive and effective Human-Building-Cluster Interface design tailored to meet everyone's needs and expectations [22].

2. **SMART objectives for effective design:** defining clear and achievable SMART objectives [26] could be crucial in designing an effective interface. Involving all stakeholders and considering the building's limitations and capabilities helps establish well-aligned objectives. Objectives are prioritised based on their impacts considering maintaining the interface development possible and viable. Best practices include regular evaluation and revision of achievement of the objectives to ensure alignment with the changing needs of the building and its occupants [20], [22].

3. **User Interface (UI)/User Experience (UX) design and technology selection**: in addition, in designing an efficient interface, it is crucial to make it user-friendly, select appropriate visual elements, and define the interaction logic for each user group. The user experience should be optimised by analysing user behaviour, and developing prototypes and user scenarios to improve interaction with the system [20]. Research has to be conducted to identify reliable, efficient, and compatible technologies while considering cost and scalability. Also, emerging technologies such as IoT, AI, and AR have to be integrated to enhance functionality and efficiency [23]. Finally, careful consideration of UI/UX design, technology selection, and system architecture is need to ensures an effective and efficient interface operation [18], [27].

4. **Back-end and front-end development**: during the implementation phase of an interface, the logic and infrastructure of the system are implemented to ensure stability, security, scalability, and optimal application performance (back-end development). At the same time, the user interface is programmed, translating UI/UX designs into working code and creating an interactive and responsive interface for users (front-end development). Best practices include having a clear installation plan, working with experienced installers, testing devices, considering future scalability, ensuring security, and maintaining clear communication with building occupants and staff [20]–[22]. By following these practices and being systematic in the development process, the HBC Interface can be made effective, efficient, and secure [23], [27].

5. **Testing, validation, and deployment**: to ensure a successful implementation, it is essential to conduct tests and evaluations, focusing on clear performance metrics, qualitative and

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quantitative assessments, monitoring tools, phased testing, stakeholder involvement, and documentation [20], [22]. These best practices help identify areas for improvement and ensure the HBC interface meets its objectives and functions [18], [23]. Once the system has been thoroughly tested and validated, it can be deployed and made available to end-users.

6. **Monitoring, maintenance, and updates**: in the life cycle of an interface, it is essential to monitor system operation, performance, and user experience. Implementing best practices, such as establishing a regular maintenance schedule, documenting activities performed, staying up to date with the latest technologies and industry standards, carefully planning upgrades, and assigning a dedicated team or individual to oversight, ensures the sustained performance and effectiveness of the interface in the long term. Continuous monitoring allows for the early identification of potential issues or areas for improvement, enabling timely adjustments and optimizations to better serve the needs of the building and its occupants [20], [23].

This comprehensive approach ensures that the Human-Building-Cluster Interface is designed and implemented to meet the needs and expectations of all stakeholders while also promoting usability, scalability, customization, accessibility, security, and privacy. Ultimately, following these best practices, it results in a more effective, efficient, and satisfying user experience, leading, hopefully, to improved occupant comfort and reduced environmental impacts of buildings.

2.2.1 Overview of the human-building interface deployed at the French pilot

The Grenoble Electrical Engineering Lab (G2Elab) is a living lab hosted in the Green'Er building that stands for the Teaching and Research on Energy in Grenoble, the French Pilot site of the COLLECTiEF project. It has been operational for several years. To allow users and the system operator to supervise, overview, and customize system control, two interfaces have been developed and are currently in use:

- A **dashboard** that allows to overview the operation and adjust control settings. This dashboard is mainly used for exploring monitoring results and to optimise the operation of the building.
    - *Basic functionalities*: The energy system in the G2Elab building is relatively complex with a large number of air handling units, heat pumps and a connection to the district heating network. Also, on the electrical side, PV panels, mono and bi-directional vehicle charging stations and electrical battery storage are present. The visualization of energy systems within the lab is achieved through a dashboard for understanding, supervising, and controlling the energy systems.

      The dashboard is mainly used by the operators to control building level modules such as heat pumps, air handling units etc.

      The dashboard is pre-configured but can be customised to explore almost any operation of systems in the building.

      The index page (Figure 1) summarises in the toolbar a large number of visualisations that can be clicked on, e.g., "comfort". Below these links, pictures show the building, and several monitoring equipment such as weather station on the roof.

      Below these pictures, key performance indicators are shown in tables and graphs (Figure 2).

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- In the different links, graphical modules can be charged to plot the current and/or historical performances of building energy systems and thermal zones. The comfort module, for example (Figure 3), allows plotting thermal comfort of occupants in terms of room air temperatures, ambient temperature, and the CO_2 concentration.

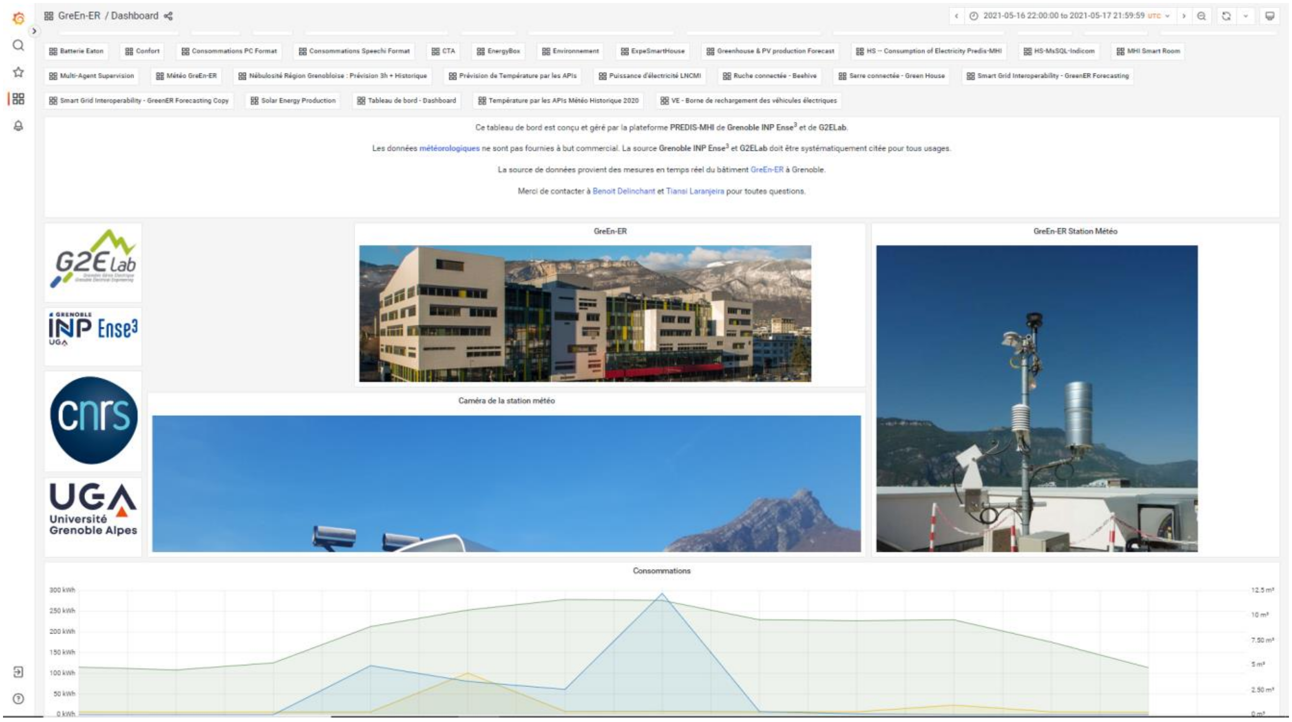

Figure 1 Screenshot of the G2Elab dashboard – Index

Figure 2 Screenshot of the G2Elab dashboard – Global overview

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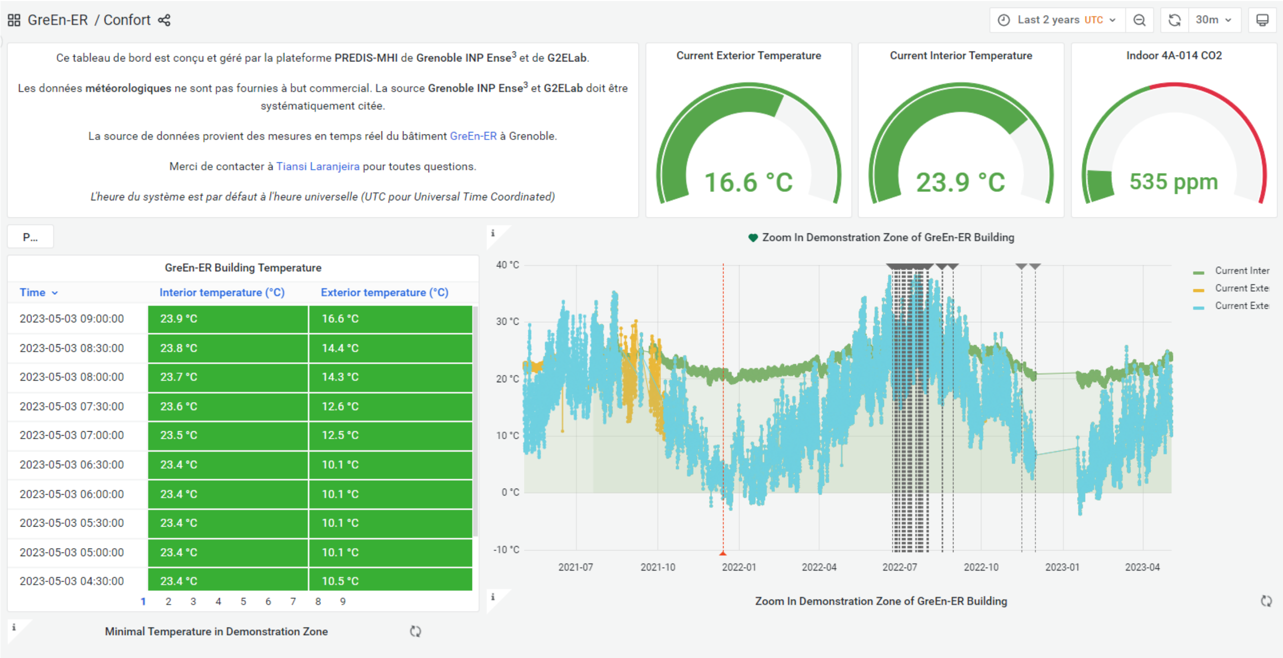

Figure 3 Screenshot of the Comfort module of the G2Elab dashboard

- An **occupant user interface** in each room allows the occupant to adjust individual settings. This second interface is available in each thermal zone (room level). The interface can be accessed via a webpage or on a physical control panel installed in the room.

  As described in the description of the pilot site, each room is equipped with the following options to heat, cool, and ventilate:
  - Ventilation: air handling units (AHU) are located on the top roof of the building.
  - (Space) heating/cooling:
    - The air is preconditioned by a coil on the level of the AHU (heating/cooling)
    - Each room disposes of a terminal coil to adjust the air blown to the room demand;
    - Each room is equipped with a reversible hydronic ceiling panel, connected to the district heating network for winter heating and local chillers for the summer cooling.

    The occupant can thus choose for their preferred way to heat or cool (air-based via AHU with terminal coils or by the radiant ceiling.

    Also, set points for room air temperature (heating and cooling) set points as well as CO_2 concentration set point are adjustable.

    Figure 4 shows the individual user interface with the following objects:

    - Choice of control mode 1,2, and 3, where mode 1 corresponds control of room air temperature and CO2 concentration using the variable air volume system, mode 2 refers to control of room air temperature and CO2 concentration using the ceiling hydronic system, and mode 3 corresponds control of room CO2 concentration only.

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- Selection of set points (left part of the interface) that correspond to the heating and cooling temperature set points, as well as the CO2 concentration set point.
- Current monitoring data in the room (supply are temperatures for water and/or air, flow rates, damper openings etc. (second left table with values). This module also allows to impose valve or damper opening percentages (in yellow)
- A graph and table with an overview of the office plan and key electric modules with measurement data (plug electric loads and lighting)

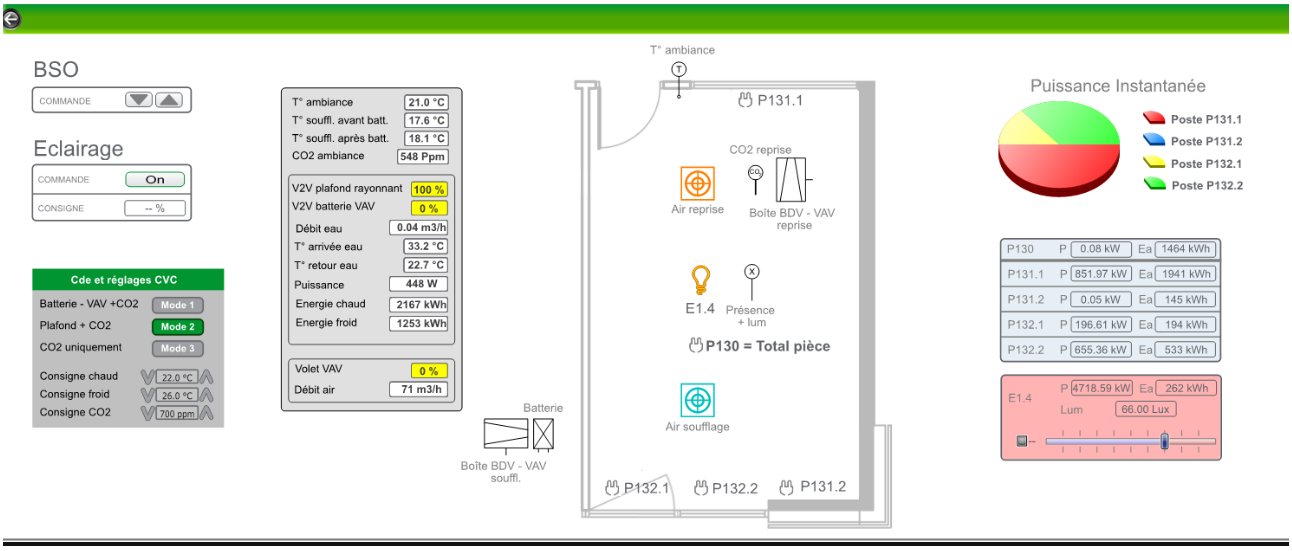

Figure 4 Screenshot of the G2Elab zone occupant user interface

- Pros and cons, limitations

However, the G2Elab occupant user interface emphasizes on providing quantitative analysis i.e., monitoring of the field data, on the other hand the qualitative assessment of the indoor environment (e.g., indoor thermal comfort, indoor air quality, etc.) is missing.

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3 The Concept of COLLECTiEF user-interface

This section presents the concept of the COLLECTiEF Human-Building-Cluster interface. The principles of user interface design are intended to improve the quality of user interface design. According to Lockwood's approach of usage-centered design [28] these principles are:

- The **structure** principle: Design should organize the user interface purposefully, in meaningful and useful ways based on clear, consistent models that are apparent and recognizable to users, putting related things together and separating unrelated things, differentiating dissimilar things and making similar things resemble one another. The structure principle is concerned with overall user interface architecture.
- The **simplicity** principle: The design should make simple, common tasks easy, communicating clearly and simply in the user's own language, and providing good shortcuts that are meaningfully related to longer procedures.
- The **visibility** principle: The design should make all needed options and materials for a given task visible without distracting the user with extraneous or redundant information. Good designs don't overwhelm users with alternatives or confuse with unneeded information.
- The **feedback** principle: The design should keep users informed of actions or interpretations, changes of state or condition, and errors or exceptions that are relevant and of interest to the user through clear, concise, and unambiguous language familiar to users.
- The **tolerance** principle: The design should be flexible and tolerant, reducing the cost of mistakes and misuse by allowing undoing and redoing, while also preventing errors wherever possible by tolerating varied inputs and sequences and by interpreting all reasonable actions reasonable.
- The **reuse** principle: The design should reuse internal and external components and behaviours, maintaining consistency with purpose rather than merely arbitrary consistency, thus reducing the need for users to rethink and remember.
- **FAIR**: that is data should be findable, accessible, interoperable and re-usable.
- **As-open-as-possible, as-closed-as-need**, meaning that the interface or data access should be "open" in order to foster the reusability and to accelerate research, but at the same time they should be "closed" to safeguard the privacy of the subjects [29], security, ownership, and intellectual property (IP),
- **Fit-for-purpose**: it has to be well-equipped or well-suited for its designated role or purpose.

Getting to the concept of the COLLECTiEF HBC Interface, we adopted the The Golden Circle Model, designed by Simon Sinek and it consists of three parts: WHY, HOW and WHAT. The WHAT part of the model describes WHAT is being done in the project. HOW describes HOW the WHAT part of the project is conducted. However, the WHY part of the model is the purpose of the project. It states WHY the WHAT part of the project is being done.

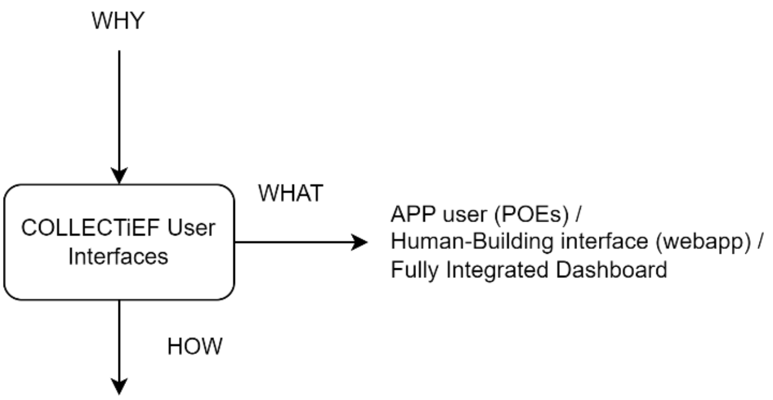

Figure 5 The Golden Circle Model for conceptualizing the COLLECTiEF user interface

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Since, the COLLECTiEF solution consists of an browser-based application implemented at (i) the building level and (ii) the cluter (i.e. the network of buildings) level, the “WHY” of The Golden Circle Model (see Figure 5) corresponds to a medium/user-interface that provides decision support to the user (i.e., occupants, building owner, facility managers, grid and energy community operators), in order to be able to monitor the operation and performance of the COLLECTiEF system. The “HOW” corresponds to the fact which each user’s profile requires different utilization and accessibility on the COLLECTiEF system led to the fact that a COLLECTiEF user interface will be designed for each user profile. To answer the “WHAT” part, we aim to design the following interface (i) a Human-Building Interface running at the Edge Node and a (iii) the Fully-Intergraded Dashboard, that can used by the building occupants, building managers/owners, and Cluster managers (buildings managers/owners, grid or energy community operators) that runs at the Cluster Node.

3.1 Architecture of the COLLECTiEF system

This section presents the architecture of the COLLECTiEF system with respect to the user interface. The Edge Node in practice is an intelligent industrial gateway based on open-hardware (HW), namely Boarder Router Intelligent Gateway (BRiG) that is installed at the building level and enables the deployment of the algorithms developed in WP2 and the communication and interoperability with the Sphensors, the Building Management Systems (BMS), smart thermostats, smart meters, and smart plugs.

By exploiting the information coming from buildings thanks to the Edge Nodes, at the Cluster Node level it will be possible to elaborate the pattern of the responses to the requested signal for flexibility sent on the base of the specific request from the energy supplier to create a predictive model for the timely communication of the signal to the right end-users to ensure the flexibility that is requested from the energy supplier is met. The Cluster Node will provide some computational means i.e., server or computer, which will combine a number of data, such as, current and forecast weather data, aggregated buildings power use data, etc. for generating the energy flexibility request signals to the associated Edge Nodes according to their energy flexibility capability.

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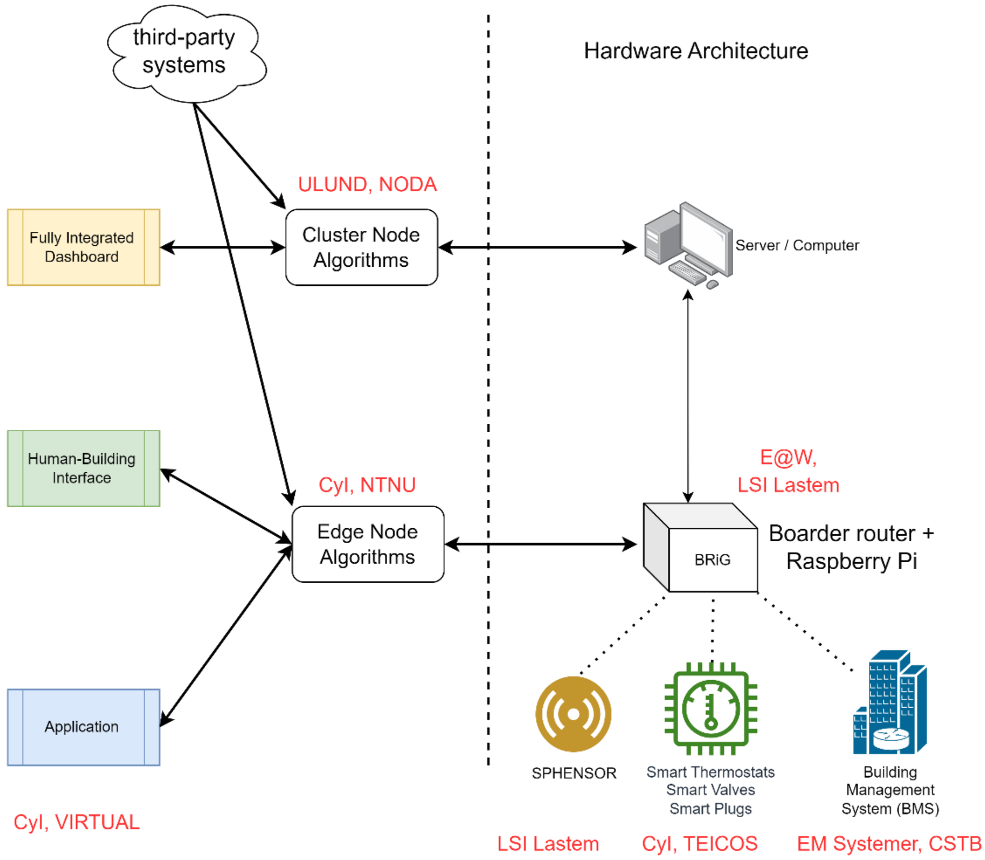

Figure 6 COLLECTiEF system architecture

3.2 Functionalities of the COLLECTiEF user-interface

The COLLECTiEF HBC Interface is developed according to the following three main user-profile classes; (i) Occupant/End-user, (ii) Building/Facility Manager, and (iii) Cluster Manager (i.e., Grid Operator, Energy Provider, Energy Community Manager, etc.). For each user-profile class, there is a dedicated user interface, whose level of access and functionalities are defined according the needs of identified for the class users. In particular, the Occupant/End-user can access a web-application (webapp) user interface that runs on the BRiG that acts at the Edge Node level. The webapp will allow the Occupants/End-users to:

I. Monitor current and forecasted weather data (i.e., for the upcoming 3 to 5 days);
II. Monitor the indoor environmental conditions of their own space/room, by accessing real-time and historical data of sensor measurements (i.e., indoor air temperature, relative humidity, illuminance, pressure, CO_2, PMx, and TVOCs) and current state of the system;
III. Monitor the key performance indicators (KPIs), which correspond
    a. For the *Indoor Environmental Quality (IEQ),* to
        i. *Thermal comfort* calculated using the Long-term Percentage of Dissatisfied (LPD) [30], which can be used with the ASHRAE Likelihood Dissatisfaction (ALD) [31], the Nicol's et al.'s Overheating risk [32] and the Fanger's Predicted Percentage of Dissatisfied [33]

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ii. *Indoor air quality* as percentage of time room is within the acceptable limits determined as follows: CO_2 based on the EN 16798-1:2019 standard and TVOCs, PM2.5 and PM10 following the WHO directions.
iii. *Visual comfort* using the Useful Daylight Illuminance (UDI),

b. the *Energy Saving*; as a percentage (%) of reduction respect to reference case,

IV. Get notifications about the predefined alerts (such sensor disconnection or low transmission signal) and user-customized alerts (such as low or high temperature).

V. Setup schedules of the COLLECTiEF system operation mode, that corresponds to a weekly time schedule in which the user will be able to customize the period of time per day in which the subunit (room) will be optimized over occupants' comfort, occupants' health, energy flexibility, cost reduction, and climate resilience by choosing between "Comfort, Health, Energy Flexibility, Economic (Eco), Resilient" mode, accordingly. The "Manual" mode, with give the option to the user to set their own set points (i.e., room air temperature reference, CO_2 level, etc.).

VI. Complete their room-associated post-occupancy evaluation (POE) and the satisfaction questionnaires.

The aforementioned functionalities available for the Occupant user will apply for the Facility/Building Manager profile through COLLECTiEF's Human-Building Interface, apart from the post-occupancy evaluation (POE) and the satisfaction questionnaires since these are location-based access. Moreover, the same information will be aggregated at the building level, in the sense of room-averaged. In addition, the Facility/Building Manager will be able to:

I. Monitor the key performance indicators (KPIs), related to
   a. the *Energy Flexibility* calculated as the change of electric load on the grid and the electric self-consumption change in case of an electric local production,
   b. the *Climate Resilience* is calculated using the Demand flexibility factor and the Agility factor, and

II. Calculate and monitor buildings' Smart Readiness Indicator (SRI).

The Cluster Manager user-profile through COLLECTiEF's Fully Integrated Dashboard will be able to:

I. Have a geographical information (map) of the buildings taking part the associated cluster(s)

II. Monitor current and forecasted weather data (i.e., for the upcoming 3 to 5 days) about outdoor of all building location, by selecting the corresponding building on the map

III. Monitor, at the overall network of buildings and at the building level, the key performance indicators (KPIs), which correspond to
   a. the *Combined Wellbeing* such as
      i. *Overall Thermal comfort* calculated as room-averaged ASHRAE Likelihood Dissatisfaction (ALD) and Long-term Percentage of Dissatisfied (LPD)
      ii. *Overall Indoor air quality* as percentage of time room is within the acceptable limits determined as follows: CO_2 based on the EN 16798-1:201 standard and TVOCs, PM2.5 and PM10 following the WHO directions.
      iii. *Overall Visual comfort* using the Useful Daylight Illuminance (UDI),
   b. the *Energy Saving*; as a percentage (%) of reduction respect to reference case,
   c. the *Energy Flexibility* calculated as the change of electric load on the grid (DP_ele,grid) and the electric self-consumption change (DE_ele,autocons) in case of an electric local production,

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d. the *Climate Resilience* that corresponds to the Demand flexibility factor and Agility factor

IV. Monitor buildings' Smart readiness indicator (SRI).

V. Monitor Flexibility signals (i.e., 0, 1,2,3,4, and 5)

			Data availablity		User Profiles					
					Edge Node Users			Cluster Node Users		
					Occupant	Facilty Manager		Grid Operator	Energy Supplier	Energy Community Manager
			Yes/No	Available temporal resolution		Consumer	Prosumer			
Enviromental parameters	Indoor	1. Air temperature	Yes	1 sample/min	x			x	x	x
		2. Mean radiant temperature								
		3. Globe temperature								
		4. Operative temperature	Yes	1 sample/min						
		5. Surface temperatures								
		6. Air velocity								
		7. Metabolic rate	Yes (POE questionaire)	twice a week	x					
		8. Clothing insulation	Yes (POE questionaire)	twice a week	x					
		9. Absolute humidity of the air								
		10. Relative humidity	Yes	1 sample/min	x					
		11. Atmospheric Pressure	Yes	1 sample/min	x					
	Outdoor	1. Outdoor air temperature	Yes	1 sample/ 10 min	x			x	x	x
		2. Outdoor running mean temperature	Yes	1 sample/ 10 min	x			x	x	x
		3. Prevailing mean outdoor air temperature	Yes	1 sample/ 10 min	x			x	x	x
		4. Global horizontal solar irradiance	Yes	1 sample/ 10 min				x		
		5. Global horizontal solar irradiation	Yes	1 sample/ 10 min				x		
	Thermal Comfort	1. PMV - Predicted Mean Vote	Yes (1)							
		2. PPD - Predicted Percentage of Dissatisfied	Yes (1)							
		3. ALD - ASHRAE Likelihood of Dissatisfaction			x	x	x			
		4. NaOR - Nicol's et a.'s Overheating Risk								
		5. Percentage of time outside a PMV range								
		6. Percentage of time outside an operative temperature range								
		7. Degree-hours								
		8. PPD-weighted criterion								
		9. Average PPD								
		10. Sum PPD								
	indoor air quality	1. Carbon dioxide (CO2)	Yes	1 sample/min	x	x	x			
		2. Total volatic compounds (TVOCs)	Yes	1 sample/min	x	x	x			
		3. Particulate Matter PMx (1,2.5, 4, 10)	Yes	1 sample/min	x	x	x			
	Visual Comfort	1. Illuminance	Yes	1 sample/min	x	x	x			
		2. Daylight Autonomy (DA)								
		3. Continuous Daylight Autonomy (DA_CON)								
		4. Useful Daylight Illuminance (UDI)	Yes	1 sample/min	x	x	x			
		5. Illuminance Uniformity (U_0)								
		6. Wienold et al.'s simplification of Discomfort Glare Probability								
		7. Hviid et al.'s simplification of Discomfort Glare Probability								
Energy Saving		1. Change of electric load on the grid				x	x	x	x	x
		2. Electric self-consumption change (in case of an electric local production)					x	x	x	x
		3. Primary energy balance						x	x	x
						x	x	x	x	x
Energy flexibility		Climate resilience and flexibility:								
		1. Flexibility Factor (DFF)						x	x	x
		2. Agility Factor (AF)						x	x	x
Discriptive data of unit (taking into account data protection, knowledge, competences of each user category)	Room	Number of thermal zones			x					
		Area			x					
		Oriantation			x					
	Appartment / Building	Number of rooms				x	x			
		Area				x	x			
		location				x	x			
		Cluster of Buildings						x	x	x
		Number of buildings						x	x	x
		buildings location, address						x	x	x
		Power Distribution Level								

Figure 7 Table of COLLECTiEF user interface requirements per user profile

Figure 7 shows a screenshot of the table of list of technical requirements used to identify the level of access and what are the options for visualizing the data for each user-profile.

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Regarding the time series data, the users of all COLLECTiEF HBC Interface will be able to select the timespan i.e., period of time of which the data will be filtered, calculated, or displayed. The user will be able to choose between last hour, last day, last week, last month, and last year beyond a custom time slice. Table 1 shows the timespan options and the data time resolution selected for each time span. An additional timespan could be the selection of a custom timespan in which the time resolution will be adjusted according to the aforementioned categories.

Table 1 Timespan options and time-series data time resolution

Analysis time span	Data time resolution
Last hour	1-5 mins
Last day	10-15 mins
Last week	30 mins – 1hour
Last month	2 hours
Last year	12 hours

The COLLECTiEF HBC Interface visualises environmental conditions and represents data in an interactive manner. The interface consists of a customizable dashboard, which allows the user to create graphs, charts and other environmental condition representing placements of their choice. The dashboard allows the user to allocate name to locations of the building layout and then allocate corresponding environment condition monitoring sensors to these locations. This sensor information can then be represented in the customizable dashboard in the form of a chart, graph etc. The user-interface has a notification function, which alarms the users of any unusual behaviours in the environmental conditions being monitored or the sensors that monitor the environmental conditions. Some notifications will be available by default, and some can be created directly by the user to address a specific condition. For example, the users will get notifications if the indoor air temperature or the relative humidity is above or below a certain value, or if an environmental condition monitoring sensor is disconnected etc. Additionally, the overall performance of environmental conditions will be represented as graphical representations, charts etc. The reward function as it described in D2.3 and D2.5, express in a combined way the energy consumption, thermal comfort, savings, and energy price. The reward function is calculated based on energy performance and thermal comfort indicator values in an area of the building during a certain time period (described more in detail in D2.5). These reward functions consist of graphical representations created utilizing received sensor data and reward function formula analysis. The user feedback option in the user-interface lets the user share feedback for further improvements of the existing system. The scheduling function of the user-interface allows the user to set different schedules throughout the day to suit their needs. The scheduling function lets the user make schedules for any/ all days of the week. Any monitored environmental parameter could be set to certain mode through different time periods of the day depending on the 5 modes of operation: Manual, Resilient, Comfort, Health and Economic (Eco), where they function differently together with sensor parameter values to optimize the energy consumption throughout the day. Figure 8Figure 8Figure 8 illustrates some of the main functionalities for each type of user interface based the user profile.

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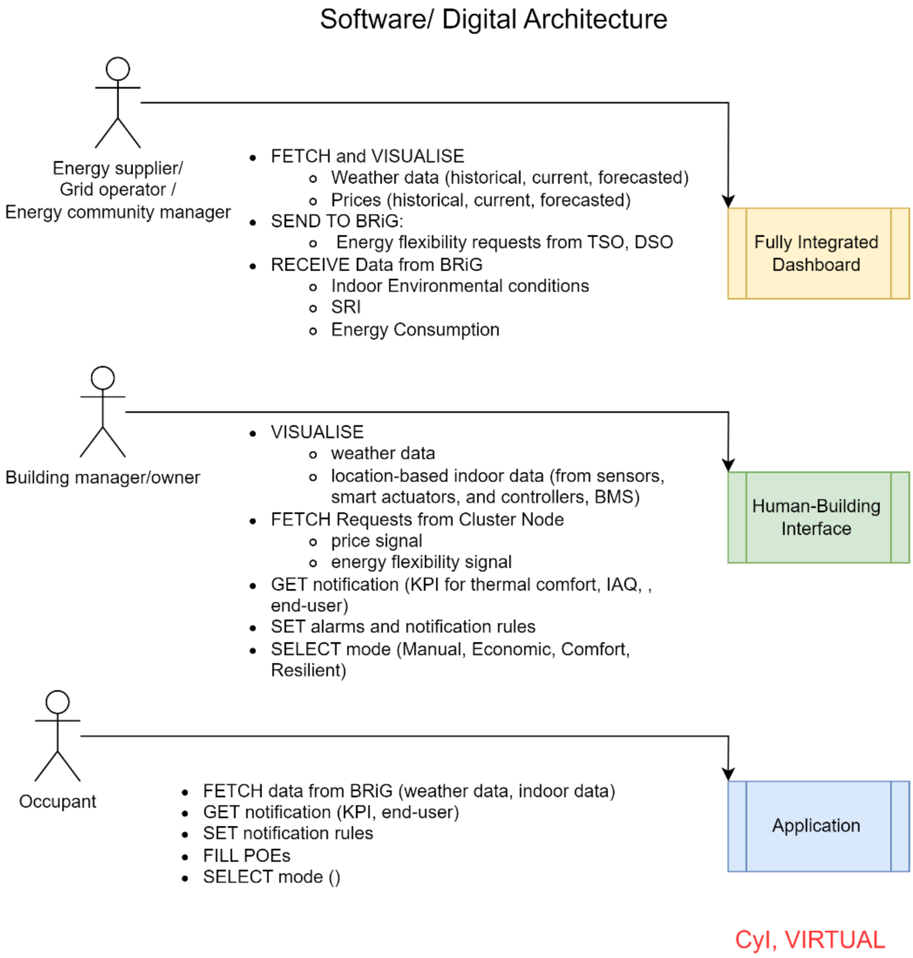

Figure 8 Main functionalities of the COLLECTiEF HBC Interface with respect to user profiles

3.3 Algorithms/Software deployed on the COLLECTiEF HBC Interface

This section presents, in high-level, the collection of algorithms that will run at the back-end of the COLLECTiEF HBC Interface. The algorithms developed under WP2, aim to meet the objectives of both the Edge Node and the Cluster Node. Specifically, the Edge Node algorithms were presented in more detail in D2.3 *Fine-tuned and feasible control strategies that address user comfort, cost & energy efficiency, climate change mitigation & adaptation (first version)*, while in D2.5 *Verified and working control strategies that maximise the occupant comfort and integration of renewable energy generation, working for current and future climate (first version),* their practical application at the small-scale pilot building was tested and verified. Please note that these two deliverables are internal documents for the technical developments within the COLLECTiEF consortium.

3.3.1 Edge Node Algorithm

This section outlines the main functionalities and the input/output information of the algorithms to be deployed on the Edge Node level i.e., the back-end of the BRiG device that will act at the level of building systems. Note that both algorithms, the Demand Side Management (DSM) and the occupant-centric control algorithm are described analytically in D2.3 and D2.5.

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- DSM algorithm
  - ***Main functionalities***: The DSM algorithm is the demand side management (DSM) or in general the energy management algorithm.
  - ***Input and output signals***: DSM works based on receiving the flexibility signal from the grid (see D2.3 for a description of the flexibility level signal).
- Occupant-centric control algorithm
  - ***Main functionalities***: The algorithm aims to improve occupants' comfort in actual operational conditions by increasing their satisfaction and productivity. For this reason, an occupant-centric control algorithm for enabling thermal flexibility by modulating the indoor set point temperature is developed. The backbone of the algorithm is state-of-the-art thermal comfort models, which are presented analytically in D2.3. The algorithm, follows a rule-based approach to activate and deactivate corrections to the online temperature set point in order to provide: (i) comfort to occupants, (ii) health improvement for occupants, and (iii) energy flexibility to the grid.
  - ***Input and output signals***: Through the COLLECTiEF Human-Building-Cluster Interface, the user will have the ability to schedule, within a 24 hours per day and 7 days a week, at both building and zone-level, the mode of operation of the COLLECTIEF system; that is "MANUAL", "COMFORT", "HEALTH", and "ENER. FLEX.". "MANUAL" corresponds to the mode in which the users have the option to choose the operation of building equipment (i.e., room air temperature set point, ventilation rate, CO_2 concentration level, etc.) according to their preferences. On the other hand, for the modes "COMFORT", "HEALTH", and "ENER.FLEX." the occupant-centric control algorithm will be activated to optimize over occupant comfort, healthy and energy flexibility to the grid without allowing indoor thermal discomfort conditions.

3.3.2 Cluster-Node Algorithms

The Cluster Node algorithm manages the performance of the cluster energy systems connected to each building of the cluster. It is described in more details in D2.1 and D2.3.

- Cluster-level DSM algorithm
  - ***Main functionalities***: The DSM algorithm is a scalable algorithm and a similar algorithm (with some minor changes based on the needs) is developed for energy management at the cluster level. Two strategies are considered in this regard: 1) minimum data transfer from the edge to cluster level, 2) sharing more data from the edge. The second approach requires a higher computational power at the cluster level since the optimum distribution of adaptation approaches for buildings are decided the cluster level, unlike the first approach which the optimum adaptation approaches are selected for the agents at the edge level are selected by themselves.

3.4 The back-end of COLLECTiEF HBC Interface

The backend of the COLLECTiEF HBC Interface is in charge of connecting the user interface with the algorithms, the data and the other components at the Edge level in an easy and interoperable way, as well as providing the functions for managing it. Figure 9 presents the architecture and the dataflow of the back-end component deployed at the Edge Node.

In order to make the algorithms able to run locally in an interoperable way with the other components of the Edge Node and with the Cluster Node, the algorithms have been suitably generalized and the input/output streams have been adapted to a JSON-based representation shared by the other

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components. The goal of this generalization is to ease the deployment of different measurement and control specifications, allowing for dynamic code use depending on the case and specific of each pilot site. The interoperability requires a degree of homogeneity for data gathering, depending on the system of collection, by defining drivers that gather and save data.

After that, the monitoring and control by the algorithm only have to interface with the common edge-node database interface rather than the specificity of each data source.

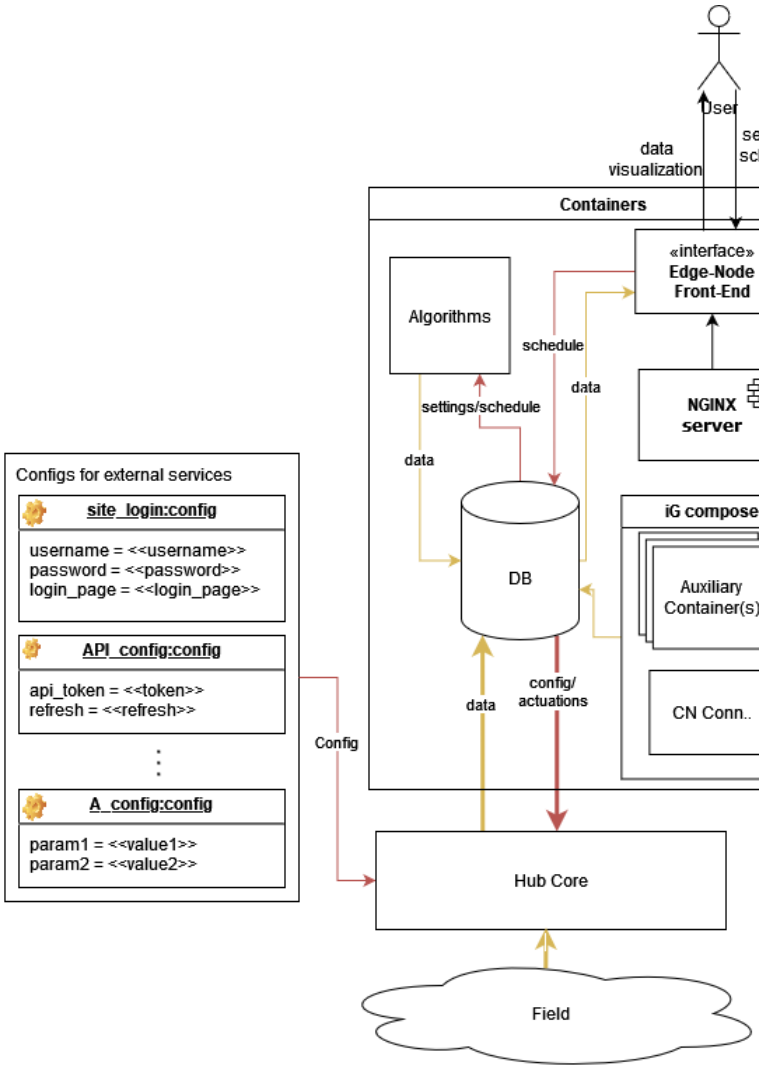

Figure 9 Edge Node simplified component diagram

Moreover, to interface with the algorithms, common interaction models between the data, the algorithms and the interface have been created based on the database schema by using a ORM and making common calls according to the requests of user input, schedule or general asset control. This will apply to the front-end algorithms as well, homogenizing data access within the Edge Node. based on the one defined beforehand, of course simplified in line with the homogenization of the data sources, to interface the algorithms with the Edge Node database (DB). In other words, the data will be stored in the Edge Node in a generalized structure in order to enable the interface of Edge Node algorithms regardless of the specificities of the building systems.

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3.4.1 Data and algorithms back-end

3.4.1.1 Software interoperability

With the aim to generalize the system and make it work independently of the data sources the algorithms have been integrated and modified in order to use a common data format and setup. In order to allow the BRiGs to interact with each and every kind of data source, a concept of abstract entity has been drawn up in order to make it interoperable regardless of:

1. the platform it works on,
2. the number of technical devices have been drawn up,
3. the abstraction of the measurement and control entities,
4. the storing of the configurations for sending/receiving data, depending on the kind of source, as well as,
5. the use of auxiliary components such as Docker Containers that may be required in order to ensure the full functioning of the algorithms.

Communication between the Sphensor devices and the back-end of the BRiG is handled by an internal MQTT broker, easily set up through docker, along with the container data. In addition to sphensors, the BRiG also handles data from other sources, which can be from API endpoints, or data scraping. It will also be important, in terms of communication homogeneity, to develop communication schemas that are compatible with the Cluster Node e.g., communications that provide a layer of transparency between the Edge Node and the Cluster Node, making sure that neither of the components require to know each other's internal structure. Starting from the MQTT exchange, the Edge Node will also be able to send its messages with a JSON format that the Cluster Node can handle agnostically, and *vice versa*, by clearly defining the methods that will be used.

Such transactions are handled by the iGateway (iG) component, which interfaces with the rest of the data structure as presented in Figure 9. More information on the iG component can be found in D3.2 - *Report on COLLECTiEF Edge Node.*

3.4.1.2 Hardware compatibility

In order to ensure hardware compatibility, it is important to generate an emulation environment where every component respects its real use. This compatibility is not an issue for the Edge Node as the BRiG component uses an identical hardware setup, made of a Raspberry PI. Such a large number of writing and reading operations on a single SD card could eventually corrupt it. As a countermeasure, it has been hypothesized to use an SSD that will be lodged inside the BRiG's plastic covering. The available space is sufficient for it, with the only problem that it will require creating a new opening in the covering of the BRiG to fit the USB cable into the port.

With the storage issues out of the way, the necessity of ensuring the data integrity requires extensive integration testing of the solutions, namely by setting up an emulation environment that simulates the sending of messages over a year or a few months in a very short time period, in order to check if the communications between components will be lossless or not, as well as find out any edge cases in the exchange and application of the algorithms.

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3.4.1.3 Integration

The deployment of the COLLECTiEF solution on the Edge Node will require for the codebase to keep account of the overall difference for each case. A common setup format has to be set up in order for the entire system to work. This starts with the definition of a common setup format in terms of building setting. The file format used for that configuration is a JSON file, which follows a format that describes the sensors and actuators in accordance with the zone they are placed in, the potential measurements, the default setpoints as well the control range of the actuators. In addition, the driver scripts will be integrated in a case-by-case scenario. A schematic setup has been studied in order to determine which site will have which driver. Each component here only requires the necessary configurations for each data source, which may even be user-supplied if, after the scope of the project, there is the possibility of adding new buildings.

Moreover, the scheduling functionality will require direct user intervention in the way algorithms are actuated depending on the schedule and thus the interface will effectively exclude or modify the way the algorithms managed by the Edge Node will operate on the spaces. For example, the user could be able to set the begin/end time each schedule, while in the case of the manual mode, the user could modify the setpoint values as well.

3.4.2 Application back-end

The back-end configuration of the user interface consists of user authentication, where unique login credential enables different users to access the interface, depending on their role as occupant, building manager/owner or grid operator/energy supplier/energy community manager. The notification function is configured to save the notification details as well as the triggering conditions of the notifications in the backend. Some of the notifications will be available by default and some will be customizable depending on the role of the user. The user feedback received from the application users is also configured to be saved, so they could be utilized for further development purposes. The customization of the dashboard by different logged in users to have their own customized charts, graphs etc. to meet their requirements, are configured to be saved, so that each user can have the same design whenever they login with their unique login credentials. The scheduled operation modes (i.e., Manual, Comfort, Health, Energy Flexibility, Economic (Eco) and Resilient mode) for every user, on a particular day or an hour of a certain day, is also saved to be implemented based on the schedules made by the user.

Node.JS environment has been used as the backend language framework and MySQL as the database. MySQL is a commercial database that uses SQL language for querying. In terms of structure, MySQL is organized into a series of tables that can store data in a structured and organized manner. Each table consists of rows and columns, with each column corresponding to a specific data field. The structure of the tables, as well as the types of data that can be stored in each field can be defined by users. MySQL also supports the use of indexes, which can help to speed up data retrieval and improve performance. These are some of the reasons why MySQL has been chosen as the database.

3.5 Front-end of the COLLECTiEF HBC Interface

The front-end functions of the COLLECTiEF HBC Interface consist of: (i) the login module, (ii) the dashboard layout, (iii) the notification module, (iv) the feedback module, (v) the scheduling module and (vi) the location assignment module. The login module is developed for the user to login to the user interface with their personalized login credentials that are used to identify the profile of the user

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that enables the corresponding level of access and functionalities. Once the user is logged in to the interface, the dashboard will visualize environmental condition parameter data in the form of graphs, charts etc. These are customizable according to the preference of the user to represent the type of environmental parameters, sensor information, locations in the building layout etc. The notification module allows the user to enable pre-existing default conditions that will trigger a notification. For example: if the temperature of a room or the humidity of a room goes above or below a certain value, a message will appear in the user interface informing the user about the change. The possibility of creating notifications will also be available depending on the type of user, e.g., occupant, building owner/manager. The feedback function lets the user give feedback on the experience using the user interface, so that further improvements could be made to make the user experience more effective. The module for scheduling lets the user create plans for different environmental parameters such as: air temperature, humidity etc. depending on the requirements. The scheduling can be very detailed on an hourly basis, and lets the user set different modes Manual, Comfort, Health, Energy Flexibility, Economic (Eco), and Resilient mode) to efficiently utilize energy consumption. The Manual mode will disable the COLLECTiEF system and will let the user define set points. Resilience mode will give priority to the requests for climate resilience from the Cluster Node. The comfort mode will maximize the indoor environmental conditions. Economy (Eco) mode will maximize the cost savings. The scheduling can be set to any or all days of the week. The user is also able to create locations for the layout of the building to represent different areas in the building. Then, the user is able to assign sensors to these locations. Additionally, the sensor data could be represented in the dashboard, in the form of a graph or chart of the user's preference.

JavaScript, CSS, HTML and React.js are some of the language frameworks used in the development of the front end. JavaScript provides interactivity and functionality when creating the web pages, CSS defines the visual styles and layout, HTML structures the content of the interface, and React.js is a JavaScript library used to build reusable and dynamic interfaces. Together with these, have formed the foundation of front-end web development of the interface, this allows to create an, hopefully, appealing, interactive, and responsive user interface.

3.5.1 Fully-Integrated Dashboard at the Cluster Node

The COLLECTiEF HBC Interface consists of a Human-Building interface that runs at the Edge Node and a fully-integrated Dashboard running at the Cluster Node.

The fully-integrated dashboard consists of graphical representations that will visualize the overall performance of environmental parameters. The data will be related to multiple buildings of a cluster. The graphical representations of reward function will consist of analysis on energy savings, energy flexibility, climate resilience and combined wellbeing. Thermal comfort and visual comfort data, along with temperature levels will also be visualized. Air quality details, sensor battery details and data transmission efficiency of sensors can also be represented. The weather data such as ambient temperature, relative humidity etc. will also be represented for each day/few days for all the buildings in the cluster (see Figure 10). The different buildings that belong to the cluster will also be represented in a map for the cluster manager's reference (see Figure 10). The cluster manager will be able to switch between different buildings to take a look at the above-mentioned sensor data and sensor battery status details etc. Additionally, once the locations are changed the updated environmental parameter details and KPI's for that location could be seen in the dashboard by the cluster manager.

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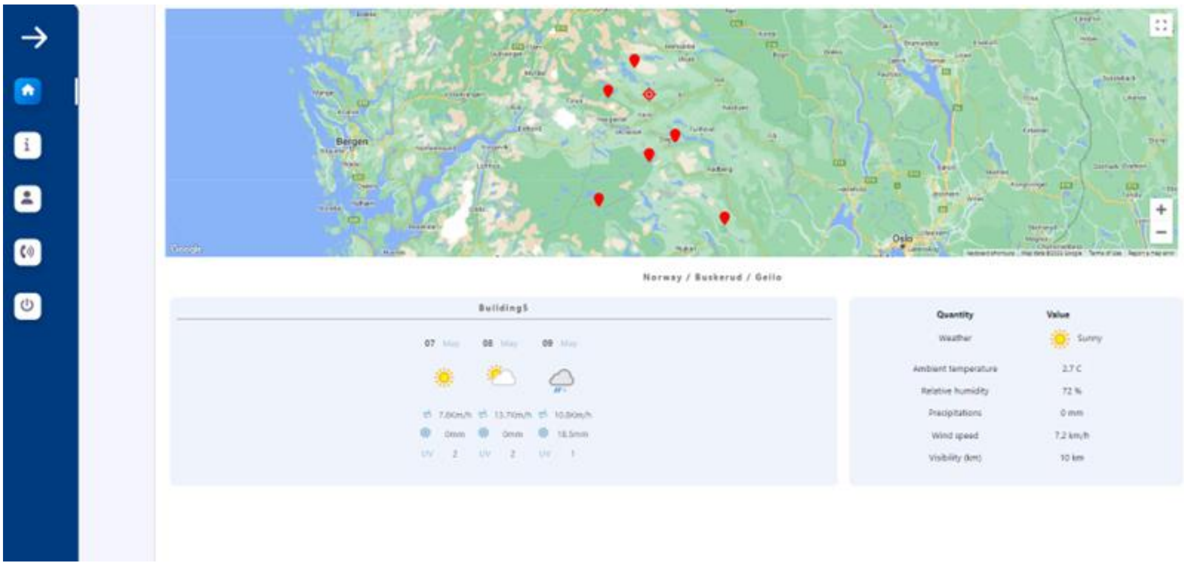

Figure 10 Weather and location information of buildings at the Cluster Node

The cluster manager is able to assign locations to different buildings or units and subunits of a building (see Figure 11). The cluster manager will select a location type (Building, unit or subunit) and then assign it a name. Once the locations are created the cluster manager is able to allocate sensors to these locations. When allocating sensors to locations the cluster manager will pick a location that was created (Building, unit or subunit) and then pick a sensor from the list of sensors that are available for the locations (see Figure 12)

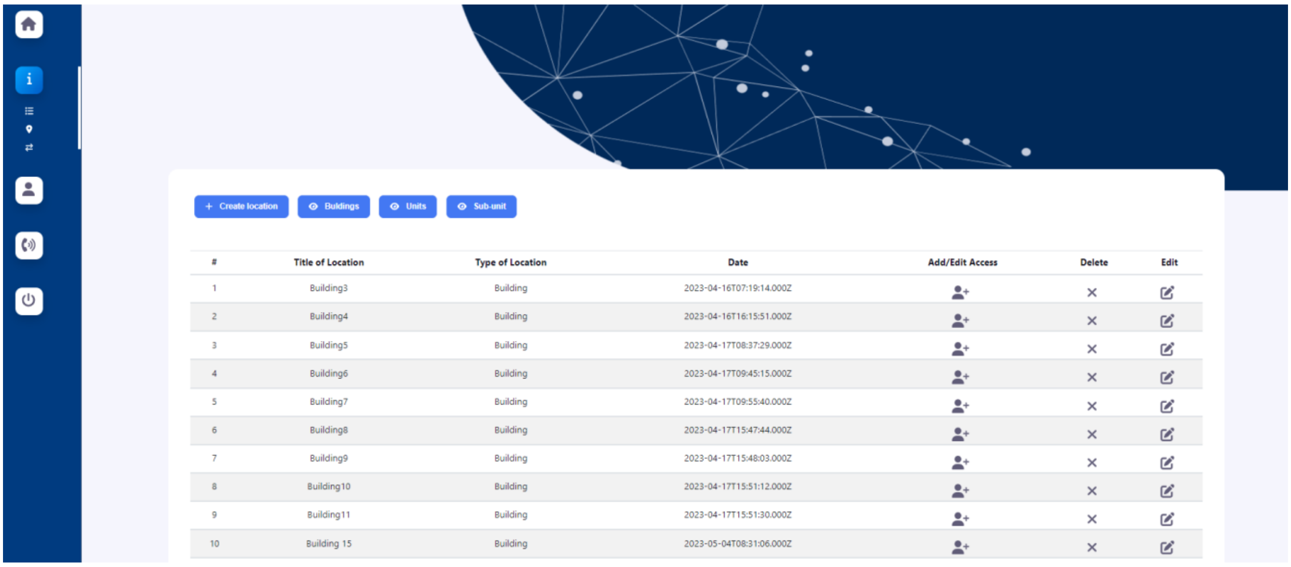

Figure 11 Allocation of locations to buildings, units or sub-units

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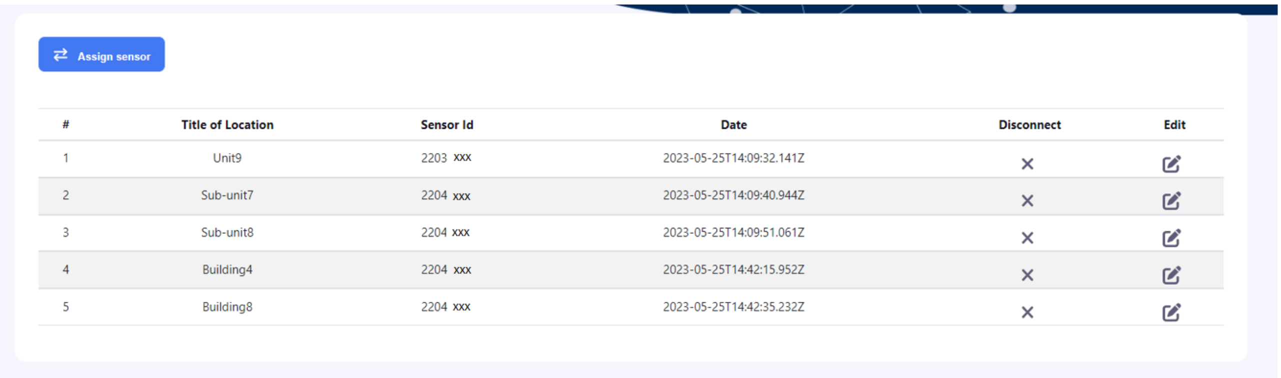
Assign sensor

#	Title of Location	Sensor Id	Date	Disconnect	Edit
1	Unit9	2203 xxx	2023-05-25T14:09:32.141Z	×	
2	Sub-unit7	2204 xxx	2023-05-25T14:09:40.944Z	×	
3	Sub-unit8	2204 xxx	2023-05-25T14:09:51.061Z	×	
4	Building4	2204 xxx	2023-05-25T14:42:15.952Z	×	
5	Building8	2204 xxx	2023-05-25T14:42:35.232Z	×	

Figure 12 Allocation of sensors to locations

The SRI calculations and results completed by the building managers/owners are also visible to the associated cluster mangers. These results will be available for all the buildings and the cluster manager is able to switch between different buildings to look at SRI results.

3.5.2 Human-Building interface at the Edge Node

The Human-Building interface has a login function that enables the users (occupants, end-users, building owners, or building/facility managers) to login to the human-building interface with their unique login credentials that consists of a username/email and password combination. Once the user's login, they can access the aggregated Dashboard that visualizes data, in form of graphs, charts, diagram, graphical and textual/numerical messages etc. that represent environmental condition information and analysis for different parameters. The Dashboard represents the geographical location of the building in a map (see Figure 14). Additionally, the weather details of the area such as ambient temperature, relative humidity, wind speed etc., are projected for few future days, while the present day's weather data contain more detailed information (see Figure 13). KPIs about the energy savings, energy flexibility, climate resilience and combined wellbeing, related to the building are available for the user to refer to (see Figure 15). Thermal comfort, visual comfort, air temperature level details, air quality details can also be referred to (see Figure 16). Additionally, sensor battery levels and data transmission efficiency of sensors are some of the other parameters that are represented in the dashboard (see Figure 17). This aggregated dashboard representation consists of information for multiple rooms/apartments of a building for the user's reference.

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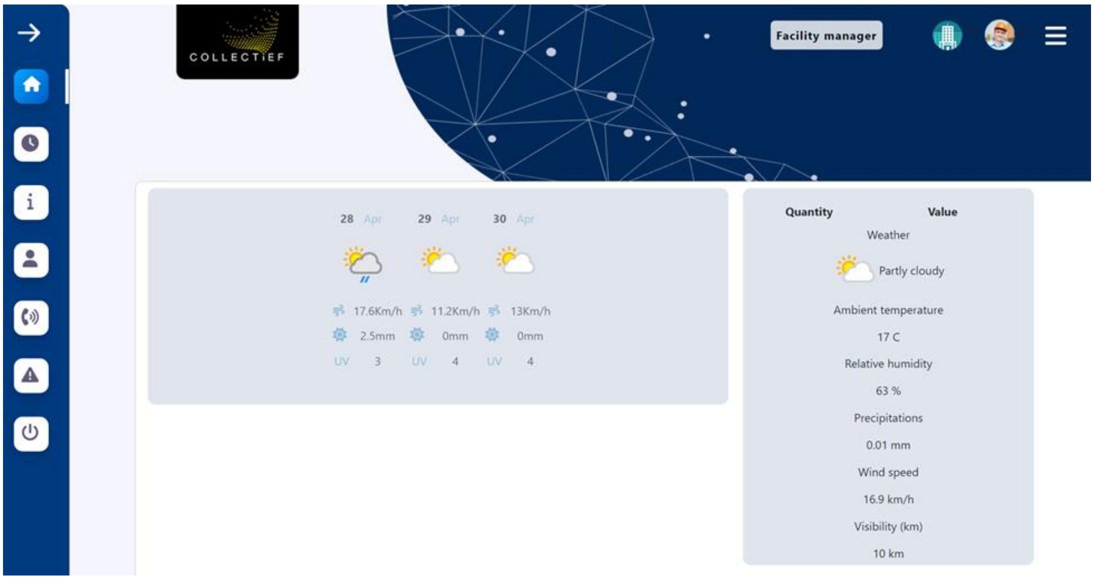

Figure 13 Weather information associated with a building

Figure 14 Geographical information of the building

Figure 15 KPIs for the building

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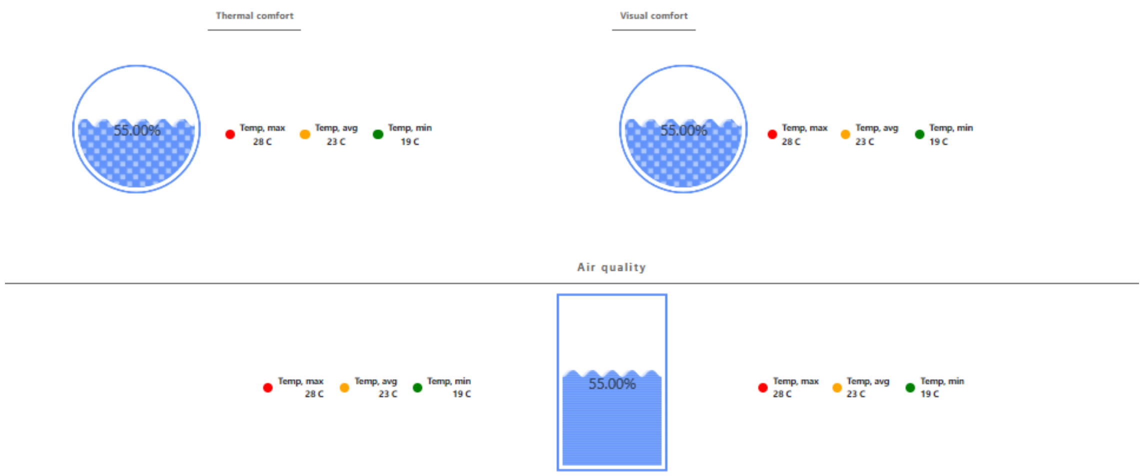

Figure 16 Combined wellbeing information such as the overall thermal comfort, indoor air quality and visual comfort of the building

Figure 17 Sensor status information

The building owner or the building/facility manager is able to create locations in different rooms or apartments in a given building (see Figure 18). They are able to choose the type of location unit, room etc. and then, give the location a name. Then to a created location, the user is able to add a sensor or sensors by selecting from a list of sensors available in the building (see Figure 19).

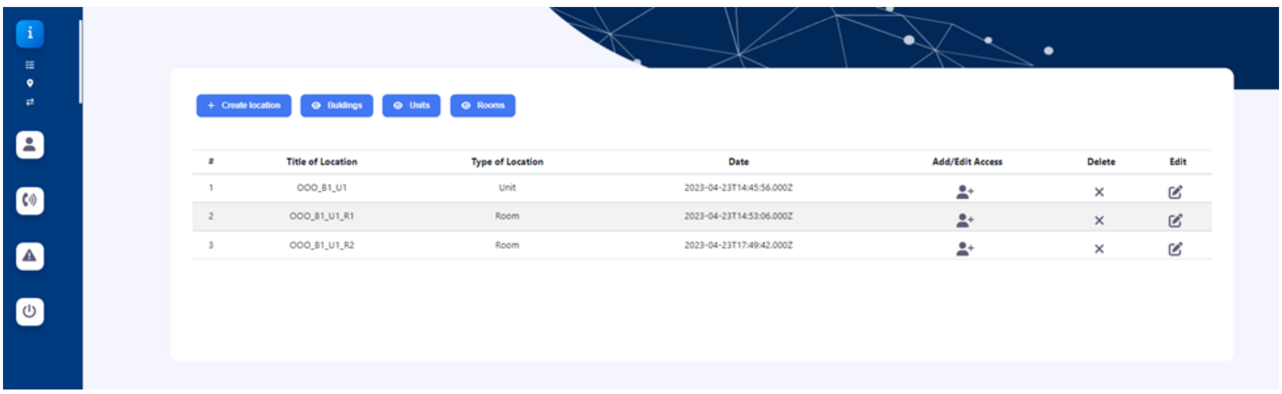

Figure 18 Allocation of locations in the building

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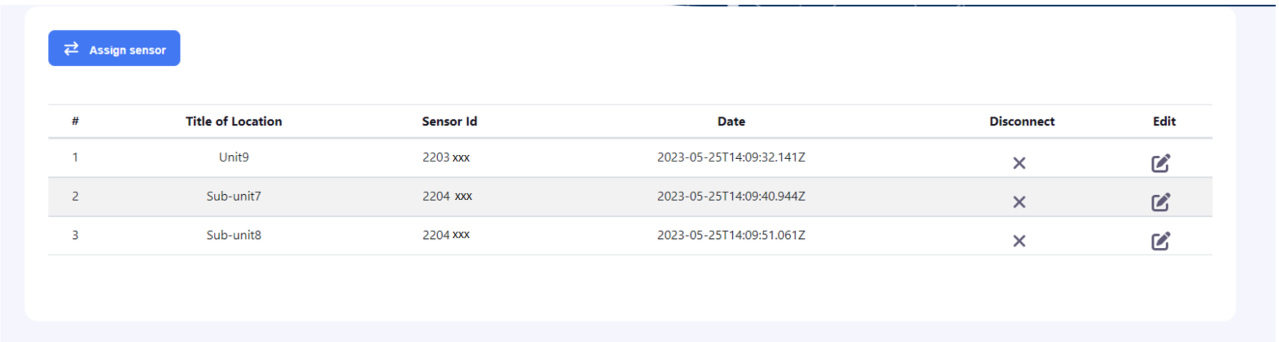

#	Title of Location	Sensor Id	Date	Disconnect	Edit
1	Unit9	2203 xxx	2023-05-25T14:09:32.141Z		
2	Sub-unit7	2204 xxx	2023-05-25T14:09:40.944Z		
3	Sub-unit8	2204 xxx	2023-05-25T14:09:51.061Z		

Figure 19 Assigning a sensor to a location

The building owner/manager is able to create login credentials and create user profiles for occupants using the User creation function, which enables the occupants to access their user interface and refer to environmental parameter and sensor information relevant to them. The user type, user email, password, name and phone number are some of the options that will be available to be filled during a user creation process (see Figure 20).

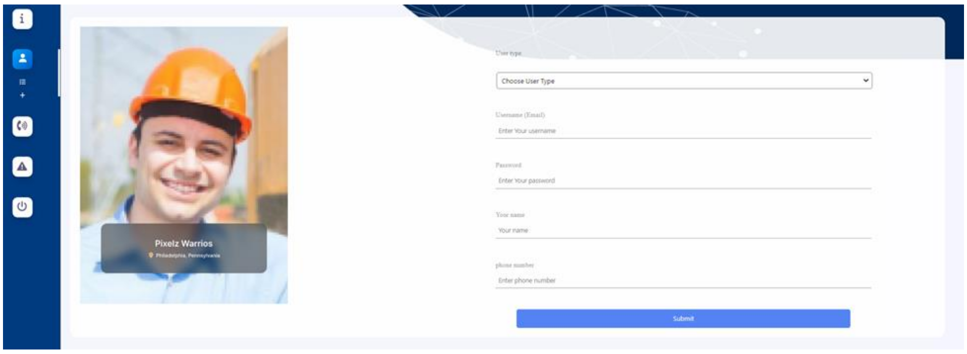

Figure 20 User creation

The building owner/manager is able to also perform the calculation of the SRI evaluation through the interface as it is illustrated in Figure 21. The option is available as a part of the dashboard, therefore the building owner/manager can easily utilize the function and get the SRI calculation results at the main page of the user interface i.e., Facility manager's Dashboard. Additionally, this information will also be available to the cluster manager to refer to, for all the buildings that the cluster will include.

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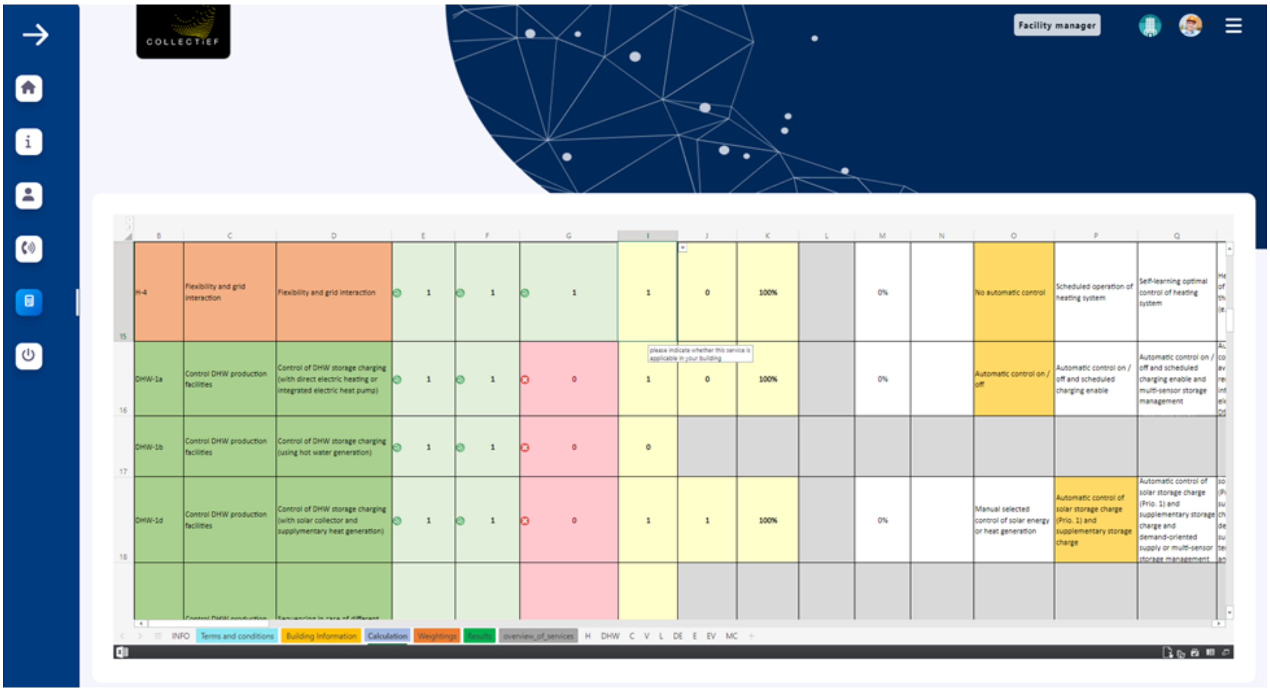

Figure 21 SRI calculation

The Aggregated scheduling modules lets the user create schedules for any hour of the day or any/all days of the week for different environmental parameters. As it can be seen from Figure 22, the scheduling tab lets the user set different modes (i.e., Manual, Resilient, Comfort, Health, Energy Flexibility and Economic (Eco) mode) to efficiently utilize energy consumption. The Manual mode will disable the COLLECTiEF system and will let the user define set points. Resilience mode will give priority to the requests for climate resilience from the Cluster Node. The comfort mode will maximize the indoor environmental conditions. Economic (Eco) mode will maximize the cost savings. The human building interface lets the building owner/manager refer to scheduling details of multiple apartments. The aggregated notification functions let the user monitor all overall notification status of multiple apartments and enable them to monitor the default notifications as well as create customized notifications. The notifications can be triggered when the environmental condition of a parameter is above or below a certain level or when a sensor is disconnected or inactive. The Aggregated feedback function let the user get feedback from many occupants of different apartments. Which will help determine their requirements for more user satisfaction and further improvements.

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Figure 22 Scheduling Tab of the Facility manager profile of the COLLECTiEF Human-Building interface

4 Concluding remarks

This report presents the status of the COLLECTiEF user interface. In particular, this report illustrates the procedure followed for conceptualizing the COLLECTiEF user interface, its architecture and main functionalities according the number of user profiles identified to meet the objectives of the COLLECTiEF solution. Moreover, this document gives an overview of the algorithms and software that run on the back-end, as well as the front-end components developed to allow user interaction with the COLLECTiEF solution’s features. Moreover, it presents the current development of COLLECTiEF user interface’s front-end.

It is noted that, at the moment, the front-end it not physically connected with the back-end components of the COLLECTiEF system, which runs on the BRiG devices. Therefore, one of the next milestones is to connect them and provide a comprehensive report of the COLLECTiEF user interface based on field data from the pilot buildings.

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