D7.2 ECF4CLIM digital platform architecture

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Who We Are

The ECF consortium consists of ten partners. The project is coordinated by Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas-CIEMAT.

Name	Country	Logo
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas **CIEMAT**	ES	
Instituto Superior Técnico. University of Lisbon. **IST**	PT	
Universidad de Sevilla **USE**	ES	
University of Jyväskylä **JYU**	FI	
Universitat Autònoma de Barcelona **UAB**	ES	
Meda Research Ltd **MedaResearch**	RO	
Instituto de Soldadura e Qualidade **ISQ**	PT	
Trebag Szellemi Tulajdon Es Projektmenedzser Korlatolt Felelossegu Tarsasag **TREBAG**	HU	
Smartwatt Energy Services SA **Smartwatt**	PT	
Que Technologies Kefalaiouchiki Etaireia **QUE**	GR	

About the Project

Through a multidisciplinary, transdisciplinary and participatory process, ECF4CLIM develops, tests and validates a European Competence Framework (ECF) for transformational change, which will empower the educational community to take action against climate change and towards sustainable development.

Applying a novel hybrid participatory approach, rooted in participatory action research and citizen science, ECF4CLIM co-designs the ECF in selected schools and universities, by: 1) elaborating an initial ECF, supported by crowdsourcing of ideas and analysis of existing ECFs; 2) establishing the baseline of individual and collective competences, as well as environmental performance indicators; 3) implementing practical, replicable and context adapted technical, behavioral, and organizational interventions that foster the acquisition of competences; 4) evaluating the ability of the interventions to strengthen sustainability competences and environmental performance; and 5) validating the ECF.

The proposed ECF is unique in that it encompasses the interacting STEM-related, digital and social competences, and systematically explores individual, organizational and institutional factors that enable or constrain the desired change. The novel hybrid participatory approach provides the broad educational community with: an ECF adaptable to a range of settings; new ways of collaboration between public, private and third-sector bodies; and innovative organizational models of engagement and action for sustainability (Sustainability Competence Teams and Committees).

To encourage learning-by-doing, several novel tools will be co-designed with and made available to citizens, including a digital platform for crowdsourcing, IoT solutions for real-time monitoring of selected parameters, and a digital learning space. Participation of various SMEs in the consortium maximizes the broad adoption and applicability of the ECF for the required transformational change towards sustainability.

Legal Notice

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1. Executive Summary

This document contains the architecture of the Digital Platform, aiming to provide a general overview, from a technical point of view, of the modules and tools that will be used to build this platform. It comprises the information necessary to define the guidelines to develop the Digital Platform and was gathered from the project members

The digital platform's architecture is being defined within the scope of activity 7.2 which belongs to the work package 7 of the ECF4CLIM Project. This project has been funded by the European Commission under the H2020-European Green Deal Call, under the grant agreement no. 101036505.

An appropriate definition of the digital platform's architecture is crucial in order to ensure an appropriate integration of all the modules and tools being developed by the different partners. In fact, this platform will be one of the means to ensure that objectives of the project are fulfilled, namely to strengthen environmental awareness amongst citizens and promote the engagement of the entire educational community in action towards behavioral changes towards sustainability.

The present document explains the Digital Platform's structure and main interconnections among modules, so that all the partners can undertake in parallel their own developments. These developments will ultimately be tied together in order to deliver the digital platform.

It shall be stressed out that this document stands as a starting point and is intended to be a solid basis for the development process. As such, this document will evolve throughout time as needed in order to face changes in the requirements or to reflect architectural decisions made by the partners involved.

2. Digital Platform Architecture

In this section it is presented a high-level description of the Digital Platform architecture detailing all the modules and tools that integrate it.

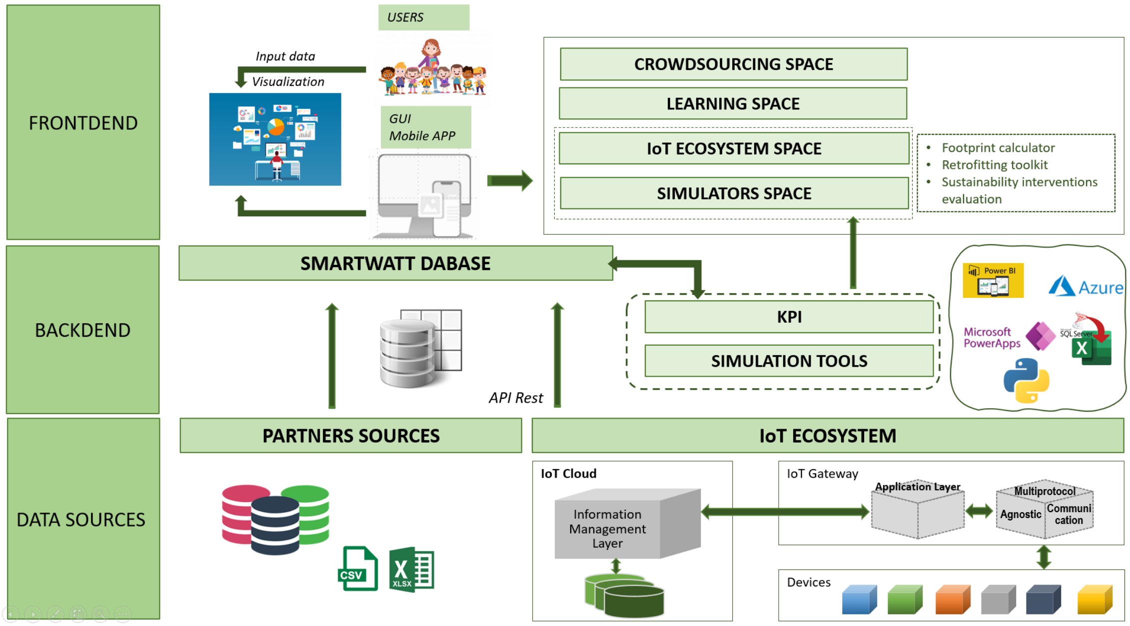

Figure 1 - High Level Overview of the Digital Platform's Architecture

Figure 1 depicts the architecture of the platform, which crosses different layers, as described following.

Data Sources

The first layer of the platform comprises the sources of information that will be used to feed the digital platform.

The main source of information to the digital platform comes from the IoT Ecosystem, which works as a data collector from the different sites, like schools, available in the project. This platform will provide data like energy consumptions, temperatures, resulting from sensors installed in these sites.

Besides the IoT ecosystem, the platform will also receive data from different sources like file-based databases (excel, csv.) from different partners. This data will then be used inside the tools available in the digital platform.

Backend

The backend is the layer responsible for the “business” logic of the platform. It is responsible for ensuring the coordination of the modules available in the platform, to make data available to the frontend and to ensure data requests to the available data sources like databases or external systems.

In this regard, the backend will comprise two main modules:

- KPIs Module which will perform data calculations on top of the data, available through all the data sources described above.
- Simulation tools where the logic of the simulator space will be included.

In order to ensure connectivity among modules, the use of Rest API technology will be used whenever possible so that interoperability is enhanced.

Frontend

Comprises all applications required to present data to the users and to enable users interaction with the digital platform modules. Overall, it will encompass two different means for user interaction:

- **Web Application:** provides a web-based application, available through the internet by using a browser. This web application will provide different views according to the user role (teacher versus student, e.g.) and well as different types of access permissions. Through this interface, all the modules developed in the project – like the simulators, crowdsourcing and learning space – will be accessible.
- **Mobile Application:** this application will be based on a hybrid application approach, which will be deployed on the respective user phone providing quick access to a multitude of different features, particularly data visualization. This mobile application can be seen as an extension of the features provided by the web application for the IoT ecosystem space. However, some modulestrans – like the Learning Space –will be best accessible via PCs , since they will not be optimized for mobile phones.

In order to ensure cybersecurity measures like data privacy, the access to data, in both mobile and web applications, will require authentication by the users. Nevertheless, it shall be pointed out that some public information can be presented such as regarding the results obtained from the project.

In the next sections of this document some of the main modules are discussed in further detail.

3. IoT Ecosystem

As previously mentioned, the IoT ecosystem is one of the main data sources for the digital platform. As such, an in-depth analysis of it is presented in this chapter. The IoT ecosystem can be divided in two main parts:

- IoT Cloud: contains the applications responsible for ensuring among others data collection from the field, device management and rule engines for data filtering
- IoT Gateway: field device which works as a data concentrator of the devices like sensors spread in the demonstration sites.

IoT Cloud

The IoT Cloud component corresponds to the framework that collects the metering and sensing data acquired from the IoT equipment deployed in the pilot sites. It provides data processing functionalities (i.e., cleansing manipulation, normalization) and enables integration and information exchange with the IoT Gateway and third-party modules. Figure 1 illustrates the subcomponents of the IoT Cloud.

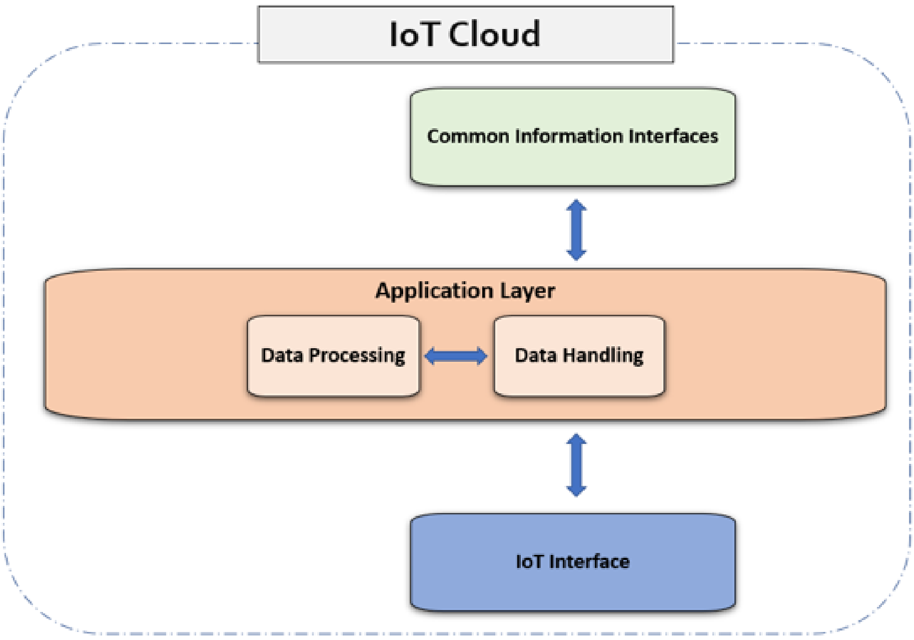

Figure 2 - Illustration of components in the IoT Cloud

IoT Cloud Application Layer

The Application Layer hosts the Data Processing and Data Handling subcomponents. The Data processing comprises all the procedures which detect, omit and/or substitute the outliers of the extracted data sets. In many cases there are data anomalies, such as sudden power consumption peaks in the datasets, due to power disruptions, connection losses or other device malfunctions. Furthermore, the Data processing subcomponent performs the appropriate transformations of data-sets to distribute them in a ready-to-process format to other components of the system architecture.

The Data Handling subcomponent acts as a communication bridge between the IoT Gateway and the IoT Cloud. Data is collected by the IoT device and transferred to the IoT Cloud through the IoT Gateway on an event-based communication. More specifically, when the metering value recorded by a device is changed by a specific amount (percentage) or an operational status is altered (ON/OFF and vice versa), a message is generated from the connected gateway and the corresponding value is identified and mapped to the respective database. If a value is not successfully mapped based on the identification process established, it is not registered in the system.

IoT Interface

The IoT Interface is the submodule responsible for the data exchange between the Application Layer and the IoT Gateway, ensuring stability and security between the components. The submodule utilizes the Advanced Message Queuing Protocol (AMQP) and the MQTT (Message Queueing Telemetry Transport) protocol in a publish/subscribe pattern for the information exchange between the Pilot infrastructure and the IoT Cloud.

Common Information Interfaces

The Common Information Interfaces are accountable for the integration of the IoT cloud to third party software modules. The module performs the Authentication and Authorization functionalities which enable a common and secure data exchange between the IoT Cloud and third-party modules. The data transmission is performed through RESTful APIs creating independence between the client and the IoT Cloud framework.

IoT Gateway

The IoT gateway acts as an interface between the physical and the digital world. In a nutshell, the designed system is embedded in a Raspberry pi computer. It hosts different software modules responsible for the stable, secure and constant communication exchange between the Device Wireless Network (DWN) that is located in the pilot sites and the IoT Cloud. In Figure 3 the software components that are hosted in the IoT Gateway are illustrated.

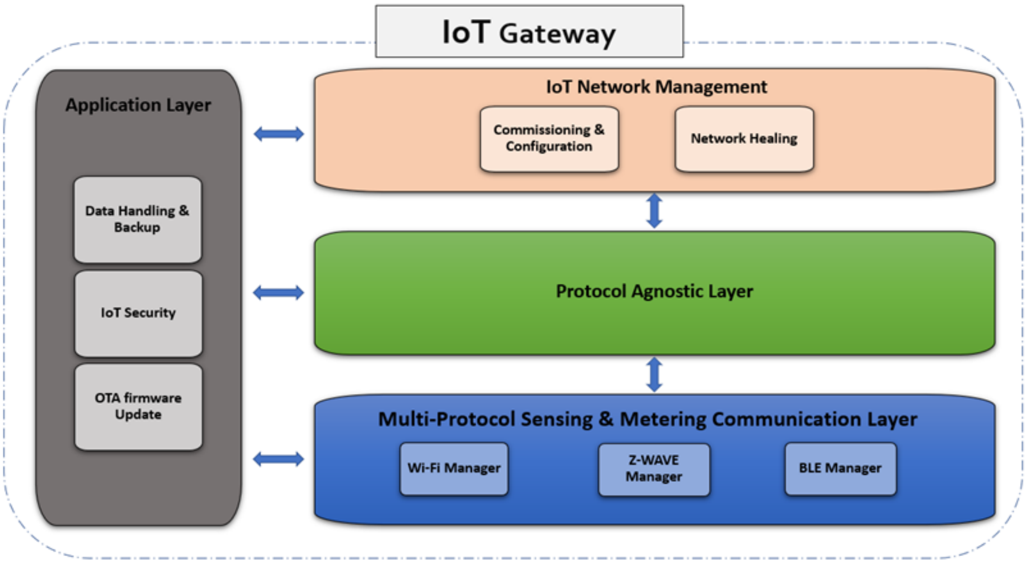

Figure 3 - Illustration of software modules in the IoT Gateway

The Protocol Agnostic Layer

The Protocol Agnostic Layer acts as a bridge between the IoT devices and the gateway. The OPEN Home Automation Bus (openHAB) is the center of the Protocol Agnostic Layer, is an open source, technology agnostic home application platform which grants interoperability by connecting various smart home devices regardless of their communication protocol with the IoT gateway.

The Multi-Protocol Sensing & Metering Communication Layer

The Multi-Protocol Sensing & Metering Communication Layer is accountable for the data handling of the gathered information of the respective IoT devices, like ambient sensing information and operational statuses. The Multi-Protocol Sensing & Metering Communication Layer also performs diagnostic tests to establish the health of the Device Wireless Network (DWN) and report potential malfunctions like connectivity issues. The Multi-Protocol Sensing & Metering Communication Layer comprises communication software modules like the Wifi Manager, the Z-Wave Manager and the BLE manager that enable integration with the IoT equipment that utilizes Wi fi, Z-Wave and Bluetooth communication protocols respectively.

The Application Layer

The Application Layer comprises the following subcomponents: the Data Handling & Backup, the Over the Air Update and the IoT Security.

The application layer includes the major services of the IoT Gateway. It includes different components that are prerequisite to establish secure information gathering and the constant functionality of the solution even if it has lost its internet connection (Data Handling & Backup). It also checks and implements all available updates (Over-the-Air firmware Update) and includes the applications that are required for the proper commissioning (Commissioning app) and data extraction operation of the IoT devices.

The components mainly utilizes the openHAB two communication channels:

- The asynchronous event bus which enables the data exchange upon event. The event might be any change regarding the operational status of a device, when a sensing or monitor data increases or decreases and when a connected IoT device is going offline or back online.
- The openHAB REST API which provides permission to retrieve all the measurements of the respective IoT devices.

The Data Handling and Backup is responsible for the circulation of the WSN's extracted data to the IoT Cloud. There are cases when the communication between the IoT Gateway and the IoT Cloud is disrupted. In these circumstances, the Backup mechanism temporarily stores the undistributed data until the communication is restored.

Last but not least the IoT Security subcomponent guarantees protection regarding the storage and circulation of data between the modules of the IoT gateway via authentication and authorization techniques.

4. Crowdsourcing Space

Through the Crowdsourcing Space all users will have an easy entry point to the appropriate crowdsourcing activity, hosted in the eDelphi platform.

Besides that, on the Crowdsourcing Space the users will be provided information about the crowdsourcing discussion guidelines. The information will be continuously updated considering that crowdsourcing is based on an ongoing multiphase discussion process.

Figure 4 summarizes the Crowdsourcing Space.

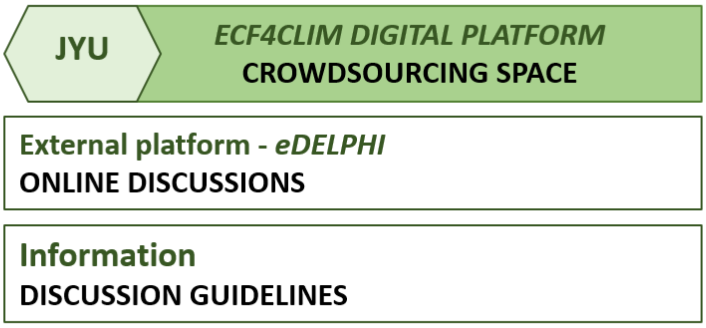

Figure 4 – Crowdsourcing space.

JYU is responsible for the crowdsourcing discussion guidelines and facilitation, and the participatory crowdsourcing platform's selection and update.

5. Simulators Space

The Simulators Space architecture is thoroughly represented in Figure 5.

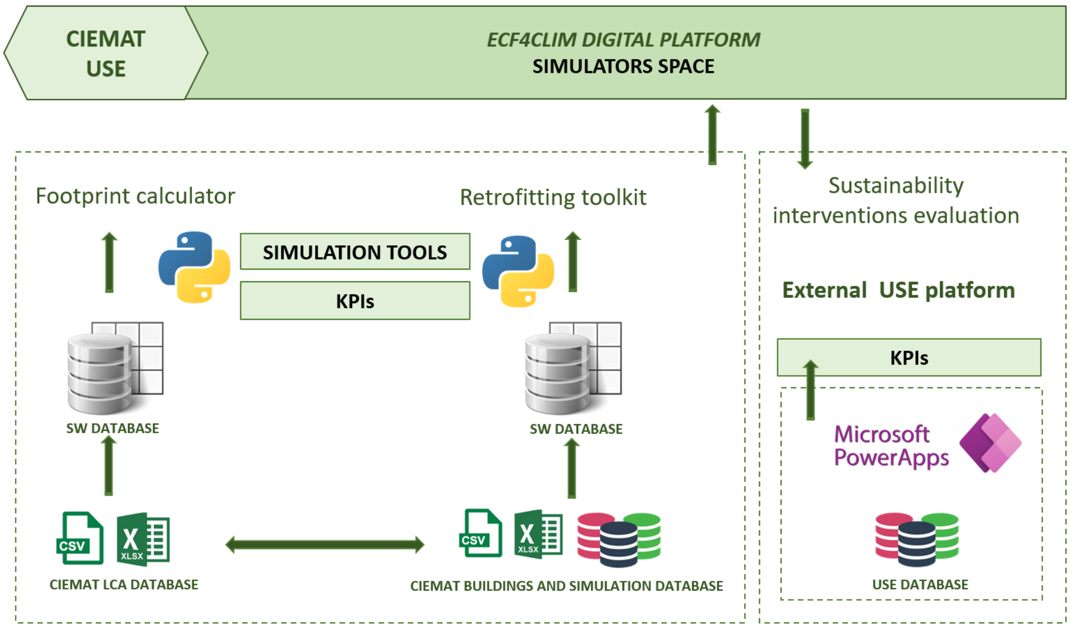

Figure 5 - Overview of the Simulators Space

Simulators Space will include a Footprint calculator and a Retrofitting toolkit.

Footprint Calculator

The Footprint calculator will be based on Life Cycle Assessment (LCA) methodology. The tool will connect the LCA baseline data and will allow users to update and simulate improvements for self-assessment. All the necessary calculations and simulations will

be integrated by Smartwatt on the backend layer using technologies such as Python. The calculations will be mainly based on the LCA database defined by CIEMAT.
The LCA database contains two types of information:

- calculations and relationship between inputs and outputs, and between process of different activities, connecting inflows and outflows, in suitable units to be connected with Impact factors
- factors calculated per unit processes to be related with impact factors

All the inputs and information on the system "EC/School" used in this module correspond to the following activities clustered by the three subsystems:

A. Subsystem EC/Building and School Management

- General data
- Electricity
- Water
- Heating
- Hot water
- Cooling
- Ventilation
- Lighting
- Gardening
- Cleaning & Maintenance
- Food Service
- Wastes

B. Subsystem Educational Activities in the EC/School

- Students' activities - classroom
- Laboratory activities
- Gym activities
- Library
- Administrative and support activities

C. Subsystem Transport and Mobility

- Outings/excursions transport
- Mobility

Smartwatt will be responsible for displaying all the necessary data and information, using adequate visualization tools in the platform, using technologies such as HTML5 and JavaScript.

Retrofitting Toolkit

A Retrofitting toolkit will also be available, consisting of:

- a dynamic building energy performance tool that evaluates the energy savings achieved by the implementation of various retrofitting measures;
- maps that assist in designing energy-saving retrofitting measures in buildings.

This first step to build this tool will be gathering and uploading the initial information from the buildings into a simulation database, hosted in the backend layer. The simulations are then performed by the users through the frontend interface. During these interactions the backend layer is invoked in order to calculate and quantify the retrofitting percentage reached by the measure selected. This tool allows the users to estimate the energy response of a representative classroom, when different retrofitting measures are implemented. These indicators, specified by CIEMAT, will be therefore calculated in the backend and displayed in the digital platform's frontend.

On the other hand, maps based on the Givoni bioclimatic charts, will also be integrated into the platform by Smartwatt as an additional way to present information to the users.

Different types of users (e.g., teachers vs students) will have access to different types of visualizations.

Sustainability Interventions Evaluation

Finally, the tool for sustainability interventions evaluation will be developed by USE using Microsoft PowerApps and will be made available to the different users through the ECF4CLIM digital platform. The tool will have different layouts according to the type of users.

The tool will provide sustainability indexes based on a multi-criteria methodology to assess the environmental performance of schools and their community. The tool focuses on seven environmental sectors: transport, green procurement, green spaces, indoor air quality, energy, water and waste – Figure 6. When using this tool, users introduce data to facilitate the participation of a wide range of people of different ages and levels of expertise and access to information related. The tool allows the users to select the measures they consider the most adequate to their local circumstances and perspectives. As an outcome, the users will obtain indicators relevant to their selected topic of interest and values of indicators.

The environment for developing the tool will be PowerApps from Microsoft – Figure 6. This application allows to create an interface between the users and the study, in which the data is saved and taken from a different SharePoint list.

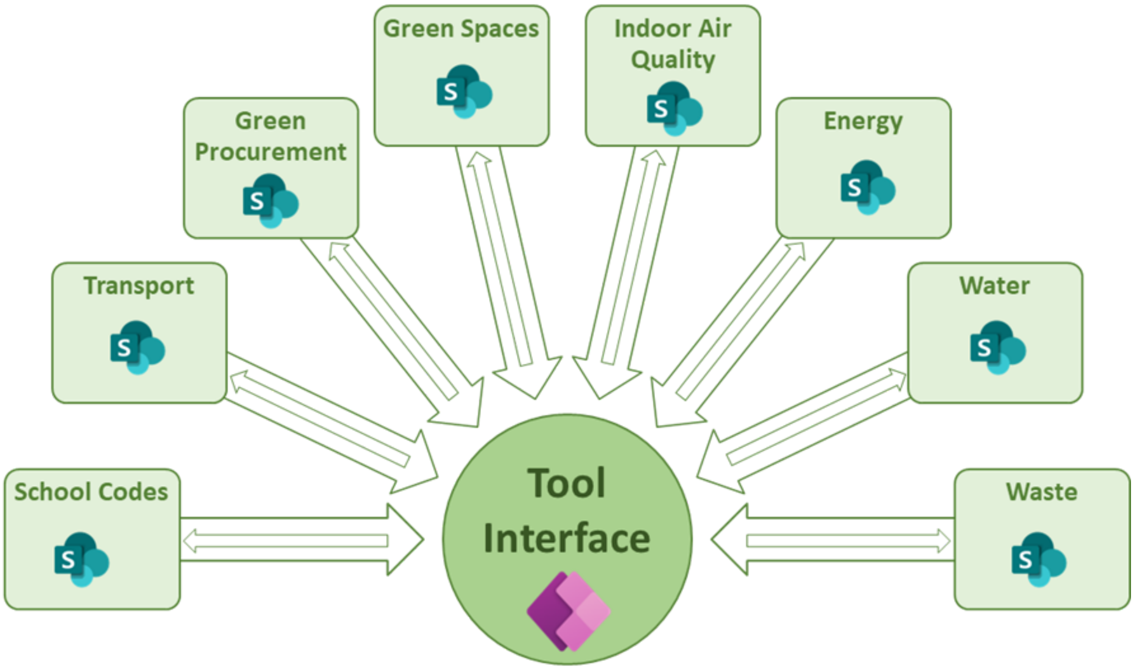

Figure 6 - Tool based on Microsoft PowerApps, focused on seven environmental sectors

This tool allows the creation of dynamic studies for the schools and under different scenarios. The user can use previously defined schools, load a new study or update the existing information. It will be designed for different levels of users (i.e. different ages, expertise in the subject, etc.), requiring different levels of information to be provided. It is based on a robust design to avoid the lack of information by the user does not preclude the study because there is a personalized study for each of the seven environmental sectors named.

Using this data storage strategy, the user can make a progressive study, including the data sequentially. Each user can only create, view, modify and delete its own data, but the calculations and the graphs displayed will be made using all the studies included in the databases.

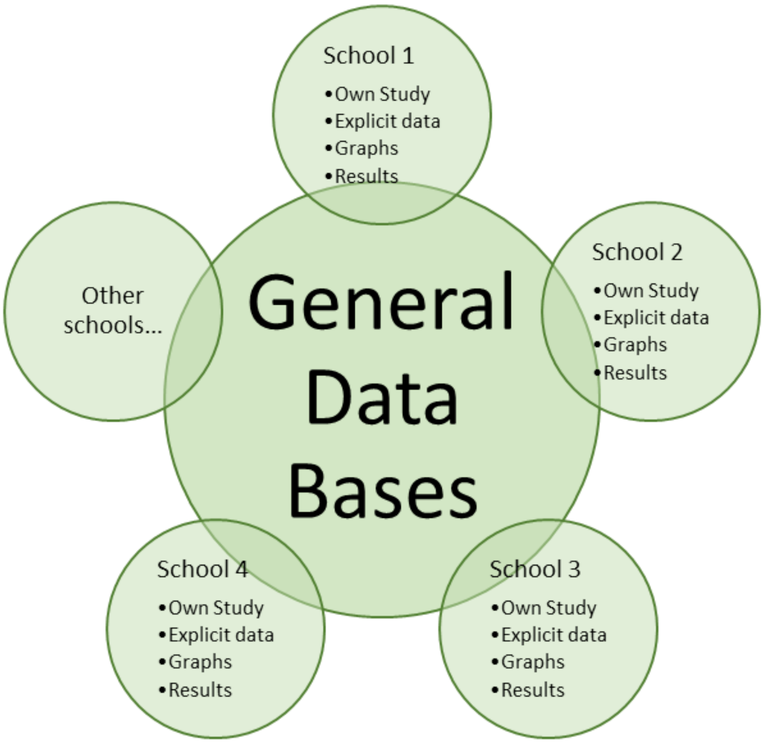

Figure 7 - Relation between Individual and global databases

Simultaneously, the different studies from different schools relate to each other, allowing for calculation of individual results or comparisons – Figure 7.

The necessary data flows in the application are carried by three Microsoft applications. The Power Apps application gives the user the interface for communicating with the databases and the application services. When the user meets all the requirements, Power Apps calls SharePoint for creating, showing, editing, or deleting data. Power Apps needs to connect to Power Automate services for creating the graphs generated for the specific study.

The information flow between Power Apps and Power Automate allows the users to view personalized graphs comparing their own cases with general studies. Power Automate needs to connect with SharePoint to make this possible, requesting the necessary information to make the graphs.

Figure 8 shows all the information flows and the necessary information for each program.

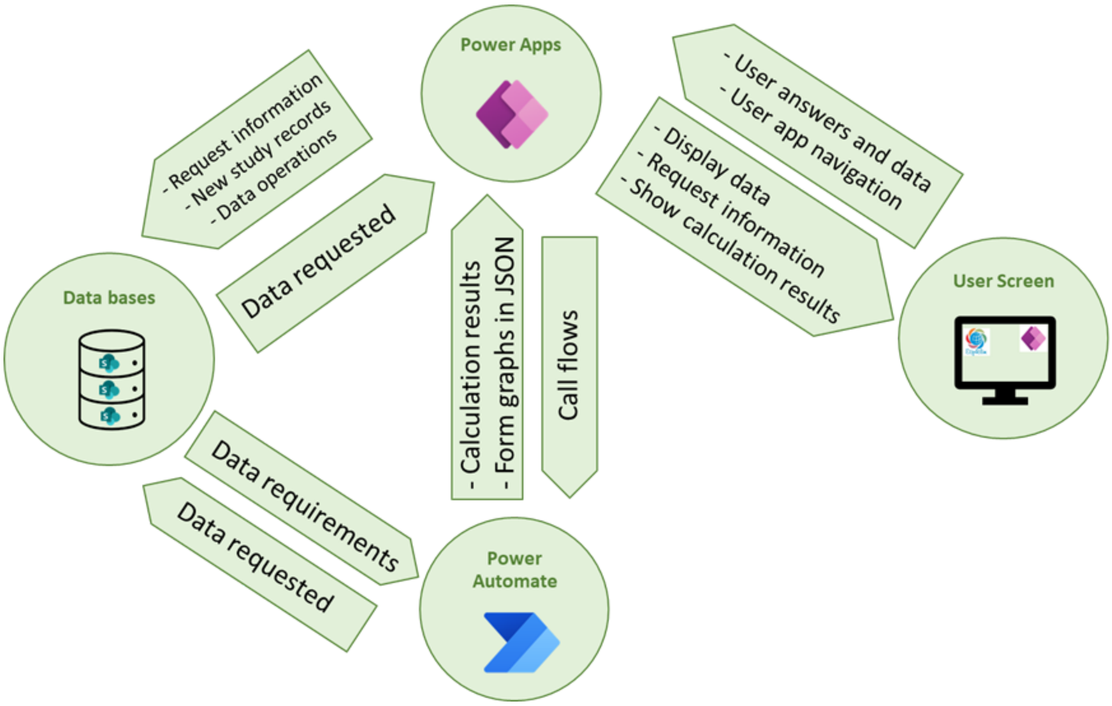

Figure 8 - Information flows and the necessary information

In order to use and share the application, users will be introduced to an Azure group to assign permissions to access databases and licenses. For those users without a Microsoft account (they are free), specific permissions will be provided to allow full access.

6. Learning Space

Through the Learning Space, a digital game, hosted in an external web server, will be made available to users via the digital platform. The learning space will be incorporated into the platform, so that users can access it in a straightforward way.

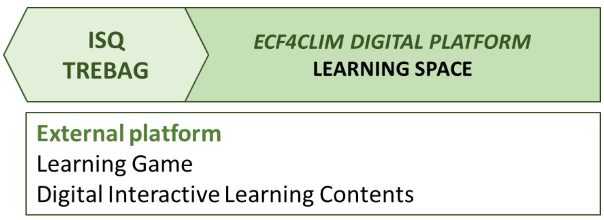

Figure 9 – Learning space.

The game will include digital learning contents and a number of minigames (quizzes, decision trees, true or false questions and memory cards, etc.).

The learning space will include several educational resources designed to improve citizens' awareness and capacity to act against climate change and towards sustainable development. These diverse educational resources will include Digital Learning Contents, and a section with links to related educational resources. The game will include digital learning contents and a number of minigames. Narratives, storytelling, and creative writing tasks will be integrated in the game.
The Learning Space will be optimized only for computer access (technical part, graphic design part, frame story) as this technical parameter was agreed at the initial state of the subcontract authorisation.
The possible types of the minigames include quizzes, decision trees, drag&drop, true or false questions and memory cards. Narratives, storytelling, and creative writing tasks will be integrated in the game, as proven ways of motivating users to play the game and study the materials. Story elements, as part of gamification, indeed occupy a vital role in today's education and even professional training.

ISQ will develop contents to different users of the educational communities. TREBAG will develop the digital game and will "gamify" the training material involving a developer subcontractor.

Further discussions shall be held in order to define the integration details of this module into the platform.