PROJECT

PRO-ENERGY – PROMOTING ENERGY EFFICIENCY IN PUBLIC BUILDINGS OF THE BALKAN MEDITERRANEAN TERRITORY

Work Package:	5. Pilot actions & Sustainability
Activity:	5.2. Integrated cloud-based joint ICT platform
Activity Leader:	Region of Epirus – Regional Unit of Thesprotia
Deliverable:	D5.1.2 Integrated cloud-based joint ICT platform

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Editor:	TREK Development		


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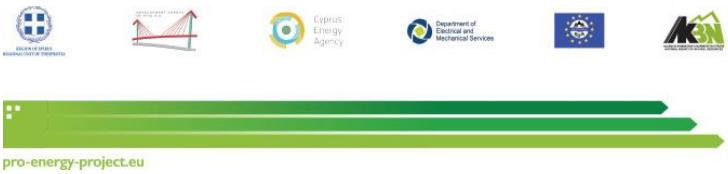
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1. Introduction

PRO-ENERGY is a transnational cooperation project, co-financed by the Cooperation Programme "Interreg V-B Balkan Mediterranean 2014-2020", under Priority Axis 2, Specific Objective 2.2 Sustainable Territories. The project aims at promoting Energy Efficiency in public buildings in the Balkan Mediterranean territory and to create a practical framework of modelling and implementing energy investments interventions, through specific ICT monitoring and control systems, as well as through energy performance contracting (EPC). The specific objective of PRO-ENERGY is to reduce by more than 20% the energy spending in public buildings of the participating entities in one year after the implementation of pilot actions.

Based on the above, Work Package 5 (WP 5) "Pilot actions & Sustainability" includes the implementation of pilot actions designed & specified in the Joint Strategy (WP3) & the drafting of a follow-up plan for sustainability of results (pilot actions, trainings) & its consultation with stakeholders. Three types of pilot actions are foreseen:

1) Design & development of an open-source Joint ICT Platform,
2) The design & development of the Joint Cost-Benefit Analysis Modeller (open to all) &
3)The joint preparation of Energy Performance Contracts (open tendering). Pilot actions will valorise results (open to all) of WP3 energy audits on selected buildings.

One public building per area involved will be equipped with smart sensor systems. An integrated cloud-based joint ICT platform will measure & analyse energy consumed at any given period of the day from different sources. Then all data & measurements (available to the wide public) will be integrated & analysed, using specially designed ICT tools, algorithms, data analytics & statistical methods, thus producing the energy consumption profile of each building.

The Activity 5.2 "Integrated cloud-based joint ICT platform" aims at the design & development of an open-source Joint ICT Platform which will guide energy consumers behaviour to energy saving actions contributing to the achievement of 20% reduced energy spending in pilot buildings & to increased energy efficiency.

1.1. Purpose

The present document provides a report of the ICT platform which was developed by the Regional of Epirus – Regional Unit of Thesprotia. The Region of Epirus – Regional Unit of Thesprotia (LP) was responsible for defining the technical and functional specifications of the integrated cloud-based ICT platform. Once the specifications were defined (D5.1), the platform was designed and finally was developed. The platform will monitor and measure the energy savings of the pilot buildings using the data provided by the smart meters.

2. Development of the ICT Platform

The PRO-ENERGY system constitutes an energy monitoring system that provides users with data about their consumption patterns, so they can make informed energy management decisions and maximize savings in their workplaces and, more specifically, in public buildings.

The PRO-ENERGY energy monitoring software gathers energy consumption data, analyzes it and then provides useful information directly to the client's devices. The software leverages a number of smart sensors, which are located on-site or in the building to gather data for each commodity (electricity, heat, water, gas) in order to provide a complete picture of energy consumption. Thanks to a series of modern energy monitoring techniques, users can keep track of how much they are consuming and how the commodity is being used at any given time of day or night.

The system was designed to ensure the most energy-efficient operation of the connected building services whilst maintaining occupant comfort. The intelligent energy monitoring system offers to its users the following two key features:

- Key Performance Indicators (KPIs): revealing valuable metrics and patterns relating to specific areas of energy consumption, the intensity of energy usage and other indicators that can be of use in establishing energy targets in public buildings.
- Energy Saving Recommendations: flagging non-optimal situations in real-time, while indicating what energy-saving measures will solve the issues that have been identified.

The PRO-ENERGY system consists of two main components: (a) an on-site component, comprising a series of smart sensors that are interconnected through a gateway and are installed on the location of each of the locations of the buildings (Igoumenitsa, Chalkida, Nicosia, Plovdiv and Tirana) and (b) an off-site component, which is a web-based application, which is essentially a web application operating on a cloud server.

The ICT Platform of PRO-ENERGY can be found in the following address:
https://platform.pro-energy-project.eu/

Respective credentials for login:

- Username: super@admin.gr
- Password: 76543217

2.1. On-site Component

The architecture of the on-site system component is displayed in Figure 1. As illustrated, the system comprises 10 smart sensors per building along with a gateway, which forwards information to the system cloud server (off-site component). The sensors will be located both outside and inside the building in order to gather data for a series of commodities (electricity, heat, etc.) in order to provide a complete picture of energy consumption.

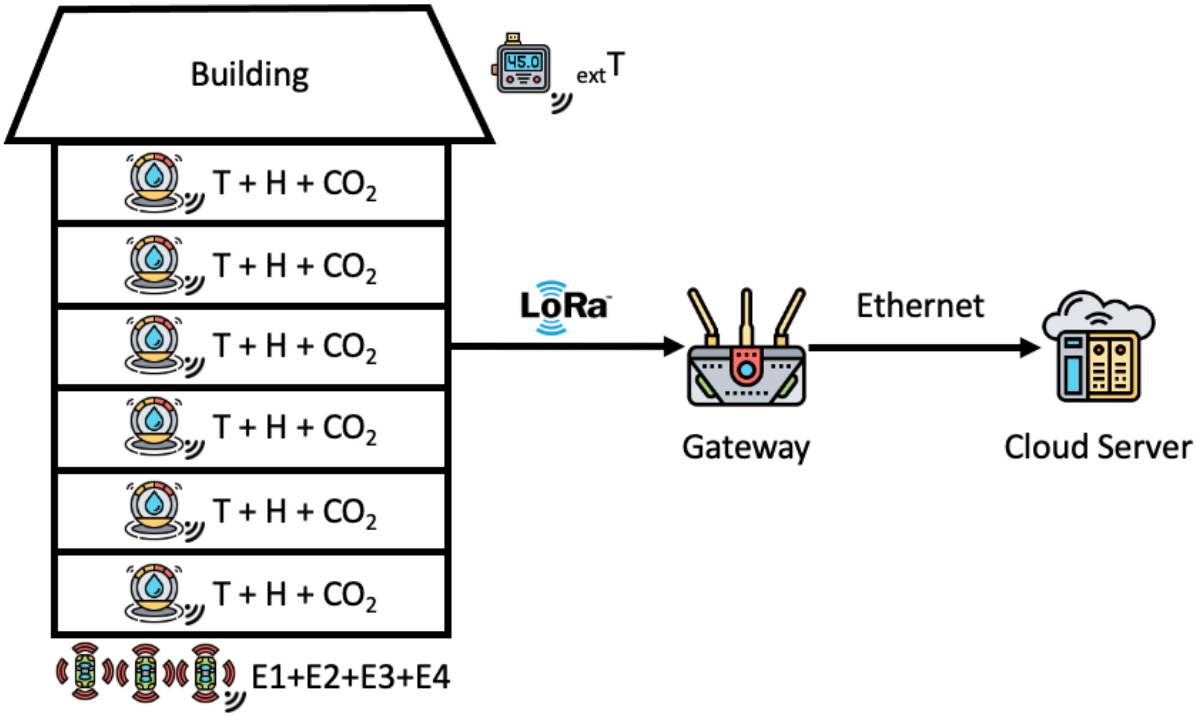

Figure 1. The architecture of the on-site component of the PRO-ENERGY system

At each building location, all installed smart sensors are wirelessly connected to a LoRa (Long Range) Mesh Network, which ensures that (a) all data transmission can be reliable under any circumstance and condition and that (b) the current smart sensor network could be easily expanded by installing additional smart sensors in the future. Using the Mesh Network, the sensors will provide structured data at preset intervals to the installed Gateway, which will then forward re-formatted data packages to the cloud server via an Ethernet interface.

2.2. Off-site Component

The architecture of the off-site component of the system is illustrated in Figure 2. The design of the PRO-ENERGY web application adopts an MVC (Model-View-Controller) pattern, which is often used to implement user interfaces, data, and controlling logic. The particular design approach emphasizes the separation between the software's business logic and display. This

"separation of concerns" provides for a better division of labour and improved maintenance. The three parts of the MVC approach can be described as follows:

- Model: Manages data and business logic.
- View: Handles layout and display.
- Controller: Routes commands to the model and view parts.

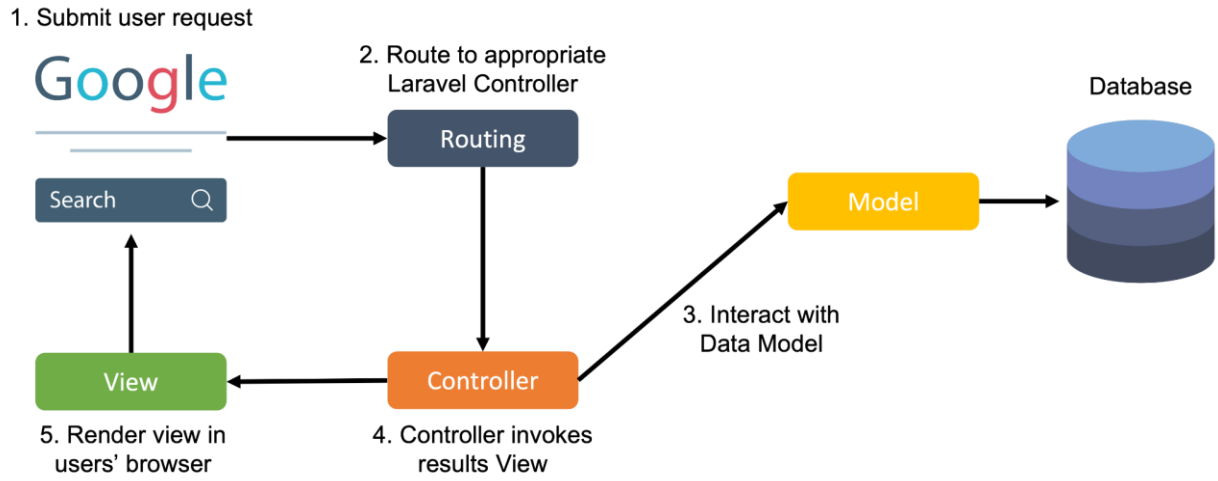

Figure 2. The architecture of the off-site component of the PRO-ENERGY system

The PRO-ENERGY Joint ICT platform application was built using Laravel v8, an open-source PHP web framework. Laravel is a modern framework that has a large community and provides powerful features such as thorough dependency injection, an expressive database abstraction layer, queues and scheduled jobs, unit and integration testing. All data will be stored in a MySQL database in the cloud server. The user interface will be developed by leveraging HTML5, CSS3, and JavaScript.

The Joint ICT platform is connected to the PRO-ENERGY project website. It also bears the corresponding Interreg Balkan-Mediterranean Program markings in order to comply with the required publicity standards of the program.

Concerning the information architecture, the structure of the web application revolves around the following list of views implemented:

- Login
- Logout
- Password Reset
- User Management
- Buildings (Homepage)
- History
- Recommendations

- About the Project
- User Account
- Contact.

2.3. User Groups

A user access level affects a user's ability to perform specific actions in the system. In fact, a user's access level depends on which rights, also called permissions, are assigned to their accounts.

The PRO-ENERGY Joint ICT platform features three main user levels:

1. **Super Admin**: system administrator who can access all buildings information and manage all users registered in the system.
2. **Building Admin**: project partners who can access the information of a specific building and manage the users of the particular building.
3. **Basic User**: managers of a building or other personnel authorized by the project partners; all these can only access information of a specific building.

It should be noted that, apart from the user management process that is available for the first two user levels, all system users cannot enter data into the system and, thus, are granted only 'view' rights. This decision contributes to data validity since all measurements data are retrieved automatically and cannot be manipulated from the web application.

3. Authorisation

Following a successful login of a user trying to access the PRO-ENERGY platform, the user is authorized by the system authorization module and redirected to the appropriate page view based on their respective user role and, thus, permissions. For instance, in case the user is a "super admin", following their login, the user lands on a dashboard displaying information and metrics about all available buildings of the system. This is not the case for the other two user types, who are only granted access to information that relates to one particular building, according to their user account and permissions.

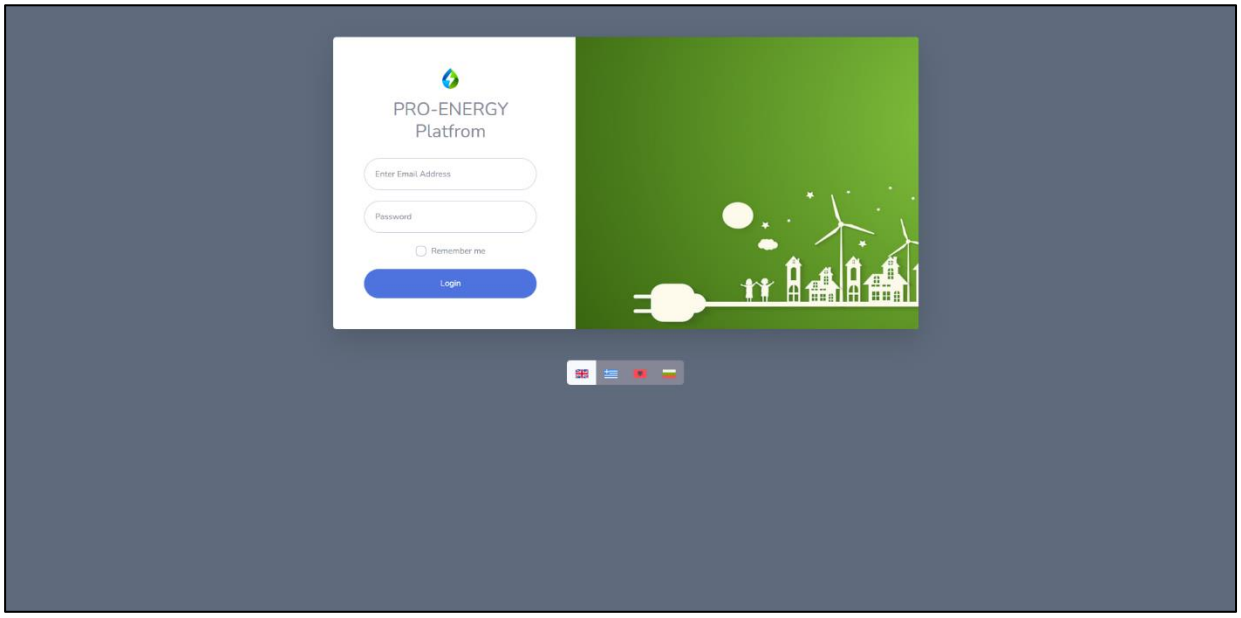

Figure 2. Users' login interface.

4. Users Administration

When an administrator is logged into the PRO-ENERGY web platform, they can access a User Administration panel, which allows them to manage all users having access to the system. Through this panel, they have the ability to select a specific building and add or edit a specific user, who may have the role of either “building admin” or “basic user”. While editing a user profile, the administrator may choose to alter their email address (username), password, role and language. Building admins entering the system can open the User Administration panel too, but they can only view and manage the members that belong in the same building as themselves. Basic users cannot access the User Administration panel, which remains hidden at all times.

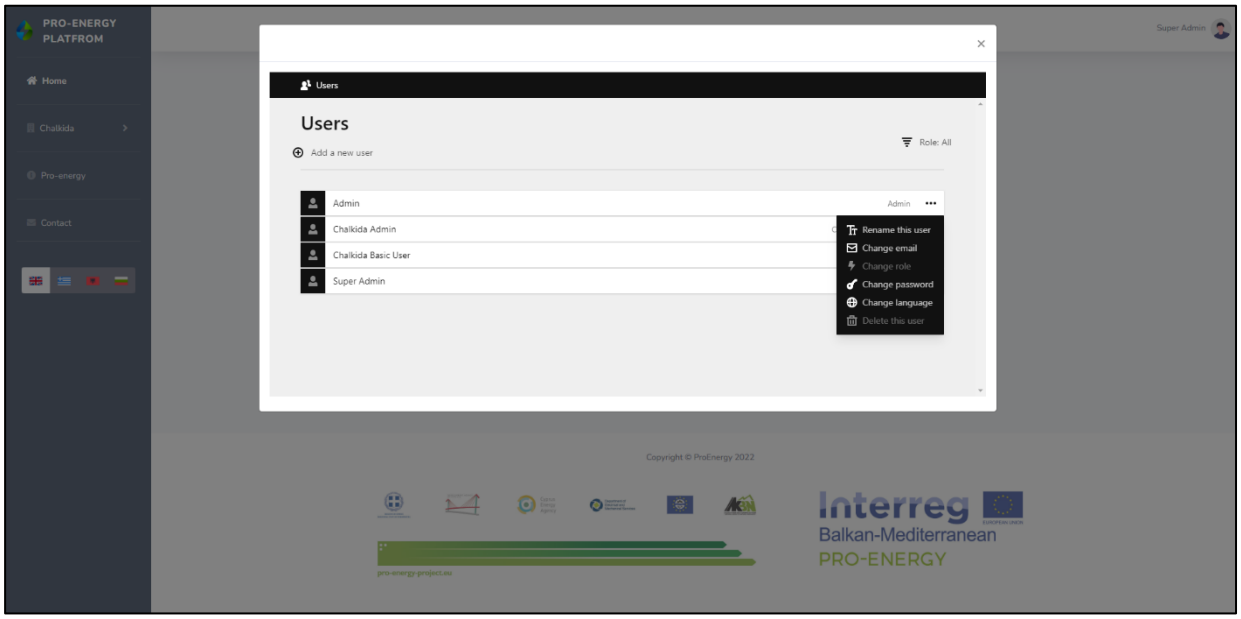

Figure 3. Users’ management (super admin interface).

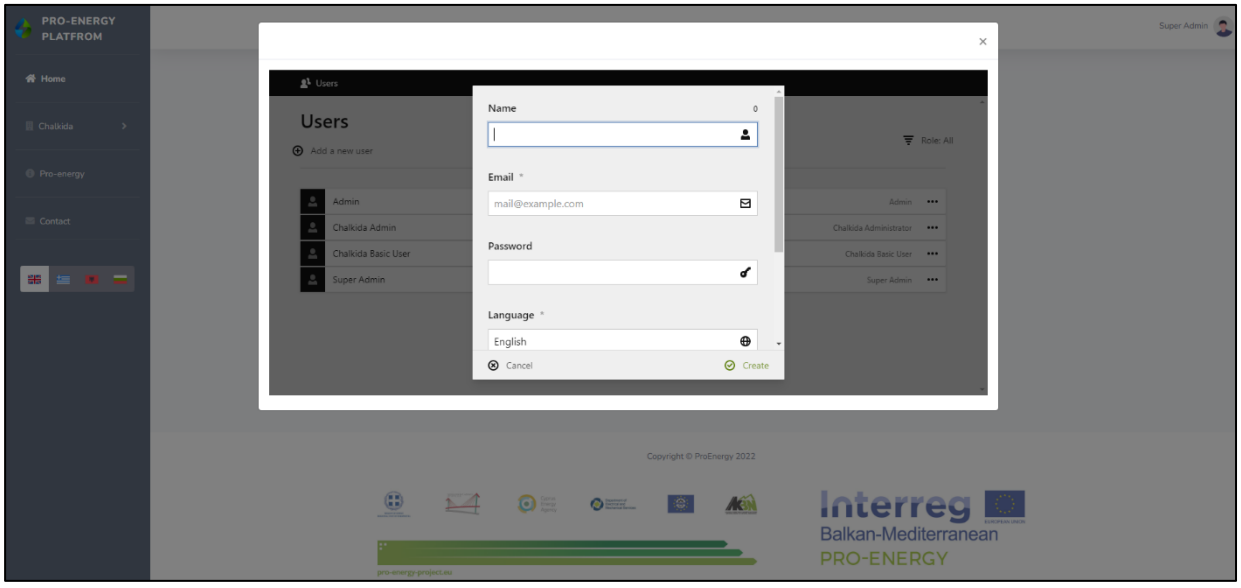

Figure 4. Users’ management (adding a new user).

5. Building Overview

In order to create an energy consumption profile for each building, the PRO-ENERGY Joint ICT platform utilizes measurements deriving from a set of smart sensors that measure: daily and monthly energy consumption, KWH / m2, outdoor temperature, indoor temperature, energy from RES in kWh, energy for charging electric vehicles per month, CO2 within the building, and indoor humidity. Following this remote data collection process, users can access a series of useful metrics via the available interface of the PRO-ENERGY web application.

More specifically users, who are logged in, have access to the buildings panel featuring intelligent reporting and data analytics. This panel presents to them all the information that is required to better manage their energy consumption, augment the efficiency of their infrastructure, optimize their productivity, increase the life of their technical equipment, reduce their energy and maintenance costs and, thus, decrease their overall impact on the environment. It should be noted that super admins can access information from all five buildings, participating in the project.

Except for the sensor data retrieved from all buildings, the system also includes a series of high-level metrics, which are described in the following Table:

Package 1
The total energy consumption in Kwh and in Kwh/m2
The energy from RES if there is a relevant system available in Kwh and Kwh/m2
The correlation will be made as a percentage of the % RES index/total Kwh
The energy required to charge electric vehicles per month
The energy required to charge electric vehicles per month to RES energy generated on-site at the building
Package 2
The outdoor temperature
The indoor temperature
The correlation of indoor with outdoor temperature and correlation with total energy consumption (month, average)

The correlation of indoor humidity, indoor temperature with total energy consumption, (month, average)

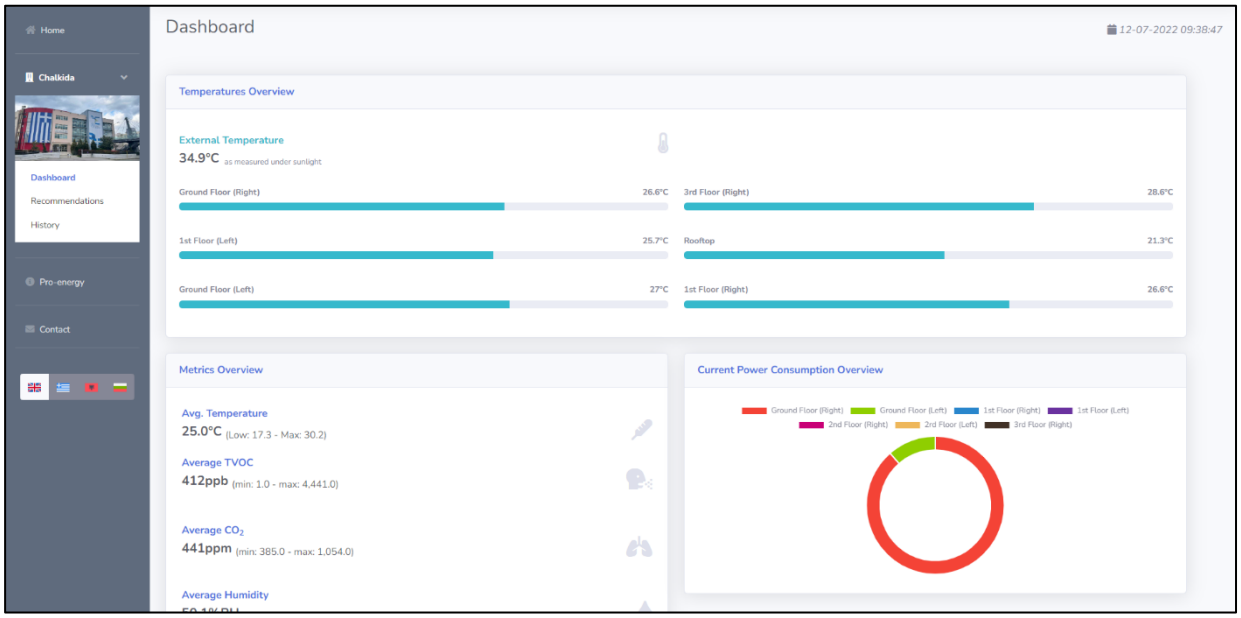

Figure 5. Building dashboard - a.

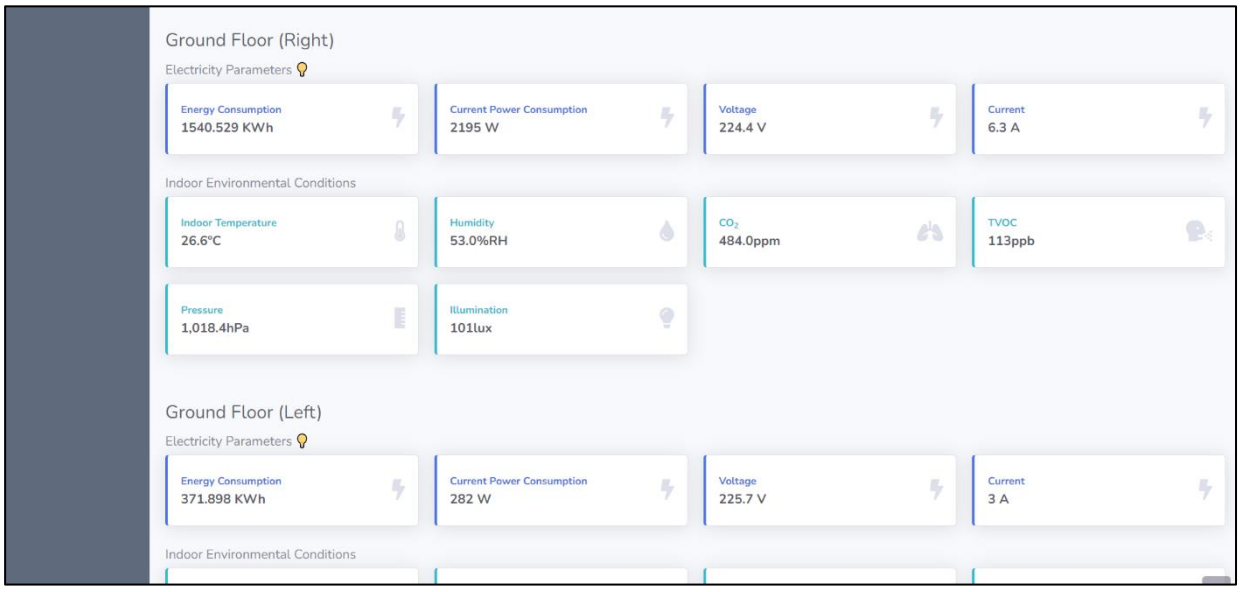

Figure 6. Building dashboard - b.

6. Recommendation Engine

The PRO-ENERGY Joint ICT platform has a unique section for presenting the recommendations generated after analysing the data gathered from the sensors of each building. The recommendation engine is a rule-based engine that shows advice for energy savings in the form of messages in a web panel. The recommendations are presented in categories, utilizing unique icons, based on the area in which they refer to. A rule of the engine can be to identify the CO_2 level of a building and if this value exceeds 600ppm then a recommendation message will be displayed to the user suggesting to ventilate the particular building. Another example of the recommendation engine operation is the lighting inside a building. The engine can employ the rule to identify whether lights are on during times when the building is not in use and then accordingly recommend turning the lights off. Additional rules employed by the engine can be found in the following images:

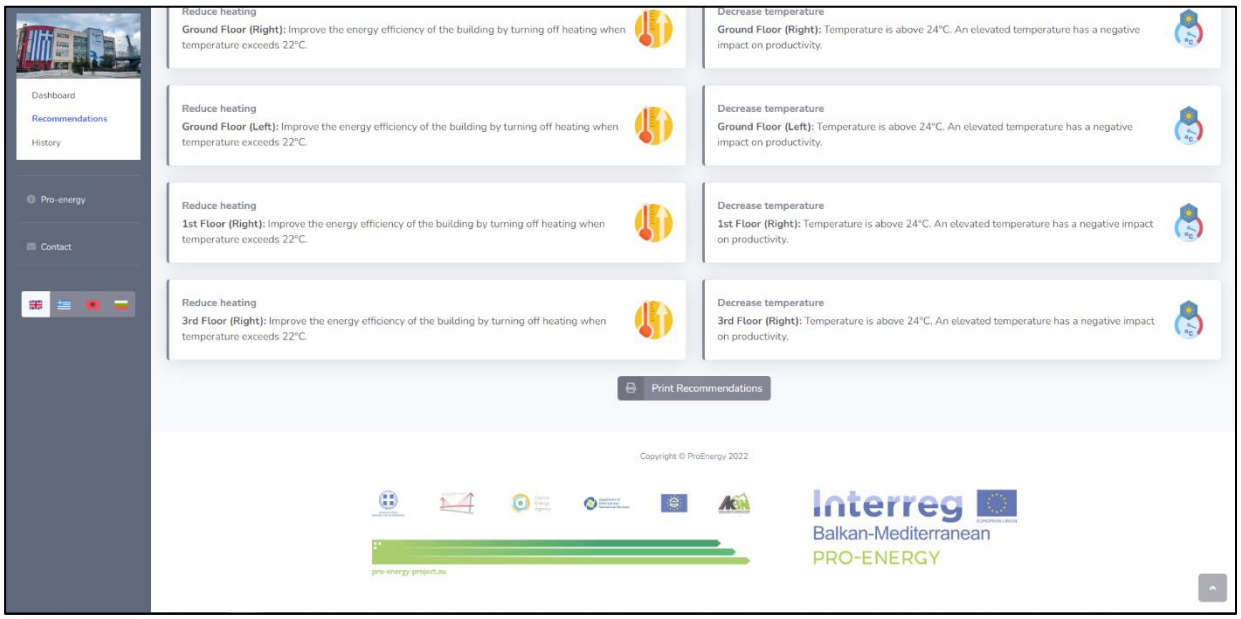

Figure 7. Building recommendations.

7. History

The end-users are able to select particular dates and the data displayed are updated based on the selection. Thus, they can check data from previous dates and acquire valuable information about changes in energy consumption which can then facilitate them to identify whether the generated recommendations were implemented successfully.

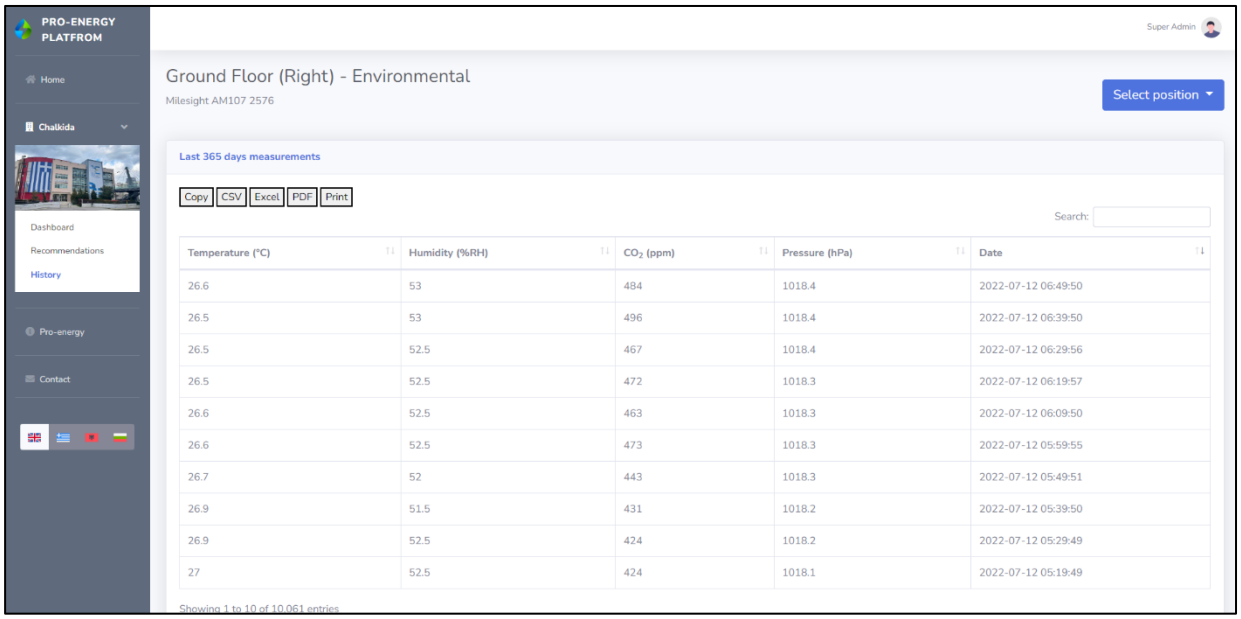

Figure 8. Building history.

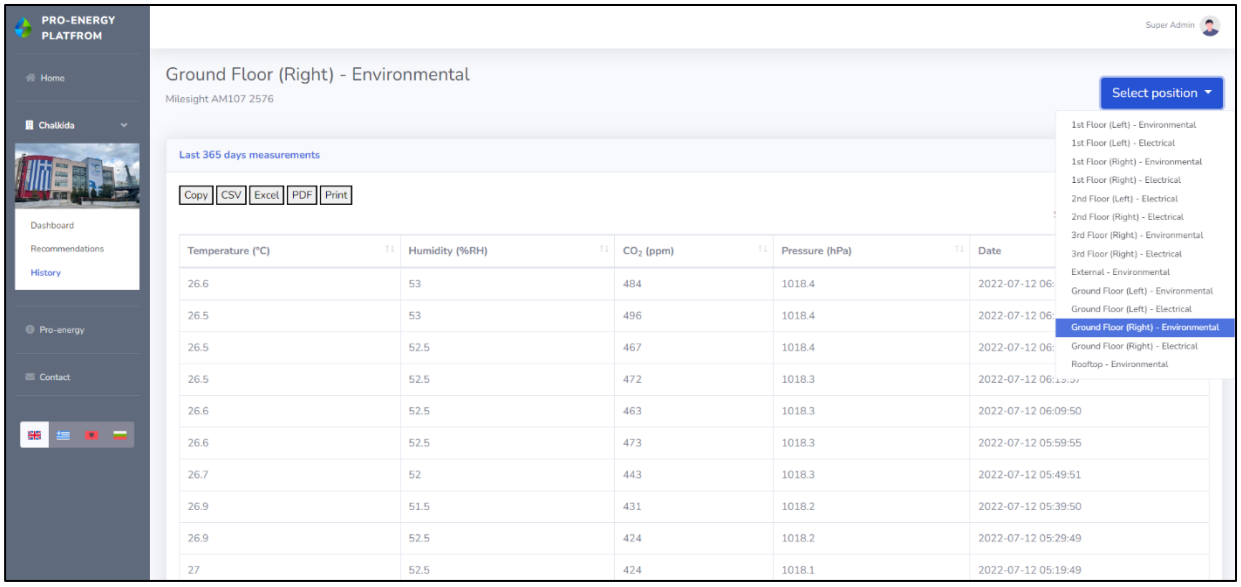

Figure 9. Building history – Select position.

8. Localisation

All users that have access to the PRO-ENERGY web application may select to view the graphical interface of the application in the language of their preference. More specifically, they can choose among English, Greek, Bulgarian and Albanian. This can be achieved by interacting with the respective language switch, which is displayed in the top bar of the interface. When a change is made by the user, the entire interface of the web application re-loads with all the appropriate language adjustments. The preferred language is also stored in the user account profile of each user, so that the system is aware of the language preference of the specific user, following their next login.

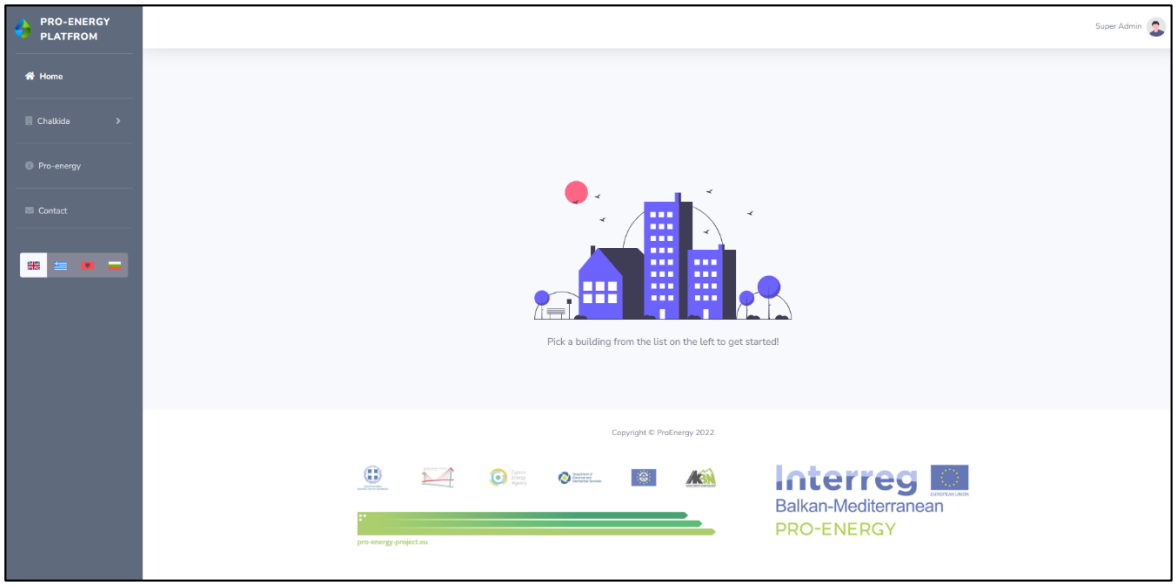

Figure 10. English language.

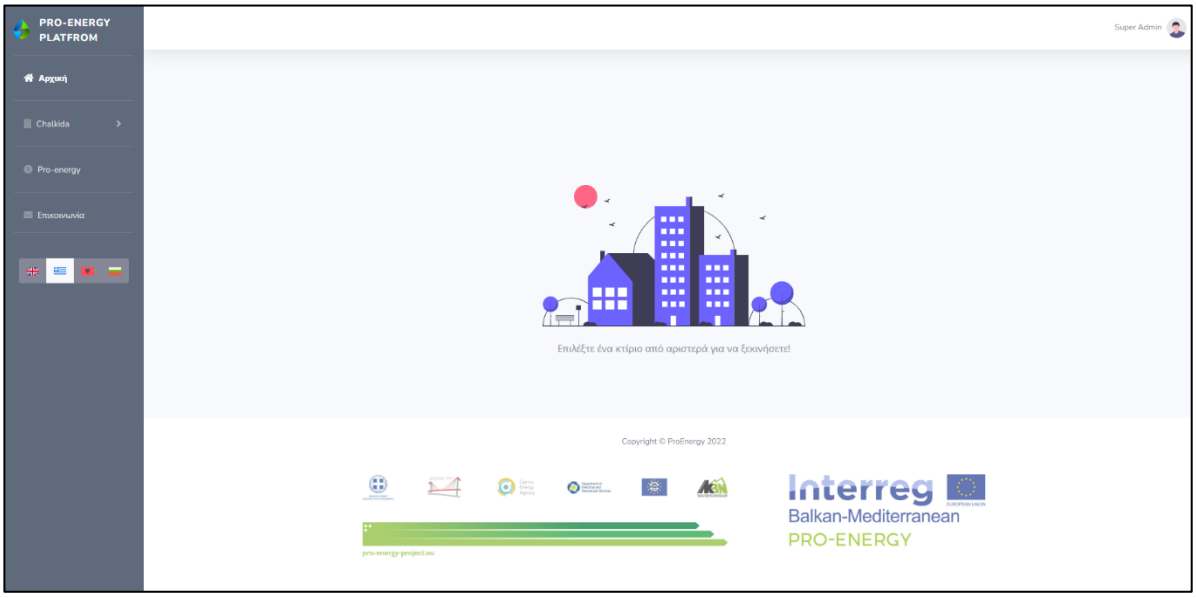

Figure 11. Greek language.

Figure 12. Albanian language.

Figure 13. Bulgarian language.

9. Other requirements

9.1. Accessibility

When websites and web tools are properly designed and coded, people with disabilities can use them. Making the web accessible benefits individuals, businesses, and society. International web standards define what is needed for accessibility. The W3C Web Accessibility Initiative (WAI) develops technical specifications, guidelines, techniques, and supporting resources that describe accessibility solutions. One of these specifications is the WCAG 2.0 standard, which is utilised in the PRO-ENERGY web platform. According to WCAG 2.0 guidelines, there are four principles that provide the foundation for Web accessibility: perceivable, operable, understandable, and robust. These principles will be incorporated into the web interface of the PRO-ENERGY Joint ICT platform as shown below:

- Perceivable - Information and user interface components are presentable to users in ways they can perceive.
- Operable - User interface components and navigation are operable.
- Understandable - Information and the operation of the user interface are understandable.
- Robust - Content will be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

9.2. Expandability

Extensibility is a software engineering design principle that provides for future growth. Extensibility is a measure of the ability to extend a system and the level of effort required to implement the extension.

In this manner, the PRO-ENERGY system must provide opportunities for future extensions, configurations and upgrades, ensuring the optimal coverage of the project requirements in the future. In particular, the platform developed adopts a series of open architecture principles in order to allow its continuous improvement and smooth expansion, without disrupting its operation.

9.3. General Data Protection Regulation (GDPR)

Throughout the system development life cycle, a “privacy-by-design” approach was employed in an attempt to provide users with the highest level of security and privacy. The web

application that was developed is fully GDPR compliant. This was achieved by making privacy and security an integral part of software product development, starting with key architectural decisions. In this fashion, the project software was designed taking into account organisational and technological safeguards, directly inherited from the Data Protection Directive, as well as capabilities that embed privacy, ensuring compliance and reducing the risks of data breach to a minimum. For instance, personal data, such as a user's email address, is be processed when there is a lawful basis for processing, e.g. consent, contract, legal obligation. Furthermore, all data are processed in a manner that ensures security and protection against unlawful processing, accidental loss and damage.

9.4. Accuracy and Validity

The system employs numerous data quality assurance techniques, including but not limited to:

- Drop-down lists with standard responses
- Masks for input fields
- Read-only access to data fields
- Record data completeness requirements
- Missing data warnings

9.5. Timing and Capacity

The system is available online 24 hours per day, 365 days per year with the exception of scheduled and pre-notified system maintenance downtimes, in case of required updates and security fixes. Data become immediately available for use.

Moreover, by employing vertical scaling, the cloud server resources will be adequate for timely response times and overall software functionality. The available ISP/hosting provider options was reviewed and once the initial development was completed the system was deployed and hosted on the most appropriate cloud server infrastructure.

9.6. Scalability

Due to the scaling-friendly nature of PHP and Laravel's built-in support for fast, distributed cache systems like Redis, horizontal scaling with Laravel is incredibly scalable. In fact, Laravel applications have been easily scaled to handle hundreds of millions of requests per month.

9.7. Usability

The platform provides an easy-to-use and understandable interface, which will allow easy access to data and information. In addition, it is based on widespread design principles, such as graphical and multimedia user interface, transparency, instant response, friendliness, and access is possible through the widely used Internet browsing applications (Chrome, Microsoft Edge, Firefox, Opera, Safari, etc.).

9.8. Failure Contingencies

The system is non-critical. Temporary inaccessibility does not create a substantial burden on any user. The host site for the system was chosen so as to include data backup capabilities and protocols. PRO-ENERGY web platform code was maintained in a git repository. Moreover, a disaster recovery plan was implemented utilising remote backups of the whole platform, including text content, media files etc.

9.9. Security

The system was developed under the leadership of TREK Development, using industry-standard web development tools and practices. TREK Development committed to developing the initial system and providing additional maintenance and security updates for the duration of the project.

There are two critical levels of security in the context of the PRO-ENERGY project: application security and server security.

9.9.1. Application Security

Concerning application security, this is one of the main reasons Laravel was selected since it is regarded as one of the most secure web development frameworks. Laravel features allow you to use everything securely. All the data is sanitized, while Laravel gives you security for common vulnerabilities. Some of them are listed below:

- **Protection from SQL Injection.** Laravel utilises prepared database statements which escape any user input that may come in through your forms. Eloquent escapes SQL commands and invalid queries.
- **Protecting Application Cookies.** Laravel auto-generates an Application Key, which uses encryption and cookie classes to generate secure encrypted strings and hashes.

This key remains secret and is not shared with anyone. Although Laravel uses this key to validate a cookie, nobody can guess it as it comprises 32 characters.

- **Cross-Site Request Forgery (CSRF) Protection.** To protect the platform from a CSRF attack, the system will leverage the Form Classes Token method, which creates a unique token in each web form. Laravel CSRF filter enables checking for a forged request and if it has been forged, it returns an HTTP 500 error.

9.9.2. Server Security

Any server on a public network can become the target of hackers. Thus, ensuring system security was an important responsibility while setting up the PRO-ENERGY cloud infrastructure, before the system is publicly available and deployment is finished. Implementing thorough and robust security measures before the PRO-ENERGY application is deployed ensured that any software running on the selected cloud infrastructure has a secure base configuration, as opposed to ad-hoc measures that may be implemented post-deploy.

The following section highlights a few practical security measures that were taken while configuring and setting up the PRO-ENERGY server infrastructure. This served as a solid starting point, allowing overtime to build an even more tailored security approach that suits the project needs.

- **SSH Keys.** Through the utilisation of SSH keys, any type of authentication, including password authentication, is completely encrypted. However, when password-based logins are allowed, malicious users can repeatedly attempt to access a server, especially if it has a public-facing IP address. With modern computing power, it is possible to gain access to a server using brute-force techniques, which automate and try a huge number of combinations in an attempt to guess the correct password. Setting up SSH key authentication allows you to disable password-based authentication. Since SSH keys generally have many more bits of data than a password, several SSH key algorithms are considered ‘uncrackable’ by modern computing hardware because they would require too much time to run through all of the possible matches.
- **Firewalls**. Even when web services implement security features or are restricted to run on specific interfaces, a firewall can serve as a base layer of protection, limiting connections to and from specific web services before traffic is handled by the PRO-ENERGY application. A properly configured firewall will be used within the PRO-ENERGY system to restrict access to everything except specific web services you need to remain open. In this manner, exposing only a few pieces of software reduces the attack surface of your server, limiting the components that are vulnerable to

exploitation.

- **Unattended Updates**. Enabling unattended updates lowers the level of effort required to keep your servers secure at all times and minimizes the amount of time that your servers may be vulnerable to known bugs. Daily unattended upgrades ensure that no critical update is missed, greatly reducing exposure to attacks.