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PROJECT

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

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Activity:	5.1. Definition of functional and technical specifications of the joint ICT platform
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IDENTIFICATION SHEET

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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.

More specifically, Activity 5.1“Functional and technical specifications of the Joint ICT platform” aims to define the functional and technical specifications of the project joint platform and present how the system will function following its implementation.

1.1. Purpose

This report explains the functional and technical specifications of the project Joint ICT platform and presents valuable information on the requested behaviour as well as how the system will function following its implementation. This document draws on a series of high-level requirements and provides technical information regarding the system architecture. Moreover, the document provides detailed functional requirements that include use cases, system inputs and outputs, as well as mock-ups. Overall, the purpose of this document is to provide useful information that will leverage the development, maintenance, hosting, and use of the PRO-ENERGY platform.

1.2. Scope

Energy constitutes a priority issue in the European Union (EU) for three interrelated reasons:

- Climate change: Combustion of fossil fuels for energy release is the most important anthropogenic source of greenhouse gases;
- Continued use of non - renewable fossil fuels on a large scale and the need to achieve sustainability;
- Security of supply: the EU imports more than 50% of its fuel which is expected to exceed 70% in the next 20 to 30 years.

Especially for buildings, they account for about 40% of the EU's energy consumption and 36% of greenhouse gas emissions. The buildings are therefore the largest energy consumer in Europe.

At present, around 35% of EU buildings are over 50 years old and almost 75% of the building stock is energy inefficient. At the same time, only about 1% of the building stock is renovated every year. Today, about 75% of the EU building stock is energy inefficient. This means that much of the energy used is wasted. Such a loss of energy can be minimized by upgrading existing buildings and striving for smart solutions that monitor and attempt to reduce energy usage.

A key goal of the PRO-ENERGY project is to improve the energy efficiency of public buildings. This is a common problem faced repeatedly in numerous regions, such as the ones involved in the project. The public buildings located in those areas often feature old installations, outdated or degraded building facades, materials and equipment (insulation, electrical appliances, cooling/heating systems, etc.), low energy consciousness, while staff members also often lack relevant energy-saving skills. All these lead to both high energy consumption and carbon dioxide (CO2) emissions. Combined with the fact that these regions are dependent on energy imports, it is obvious that there is much room for improvement as regards energy efficiency. Most importantly, the exemplary role of the public sector must be promoted by increasing energy savings in public buildings.

The PRO-ENERGY project attempts to address the aforementioned problems by developing and implementing a common strategy and action plan. The latter aims to improve the energy-saving skills of public building owners and managers, developing and implementing technologies and tools to reduce energy consumption, and promoting good practices that can be valuable for local/regional/national entities in the Balkans and the Mediterranean.

The innovative energy monitoring platform created under the prism of the PRO-ENERGY project aims to alter consumers' self-awareness and behaviour in a way that leads to reduced energy consumption levels. As suggested by the literature, programs that address consumers' energy-saving behaviour can serve as a cost-effective way of reducing energy consumption. Still, to achieve this, consumers must be provided with meaningful, clear and continuous feedback and instructions.

PRO-ENERGY focuses on non-household consumers - i.e. workers in public buildings - because in this target group the initiatives are usually provided at the organizational level and there is no direct connection with their personal wealth. The motivation for these users to engage in energy-efficient behaviours is therefore very different from that of home users and also involve corporate and social responsibility policies. Incorporating measures that target behaviour change at the workplace can inspire consumers to act differently at home, thus contributing to even better energy efficiency.

Against the above, this Functional and Technical Requirements document outlines the functional, performance, security and other system requirements identified as the proposed solution for the PRO-ENERGY system. The scope of this work includes details that describe the initial design and development of a web-based system, based on a series of information and feedback gathered.

2. SOLUTION OVERVIEW

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 is 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.

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.

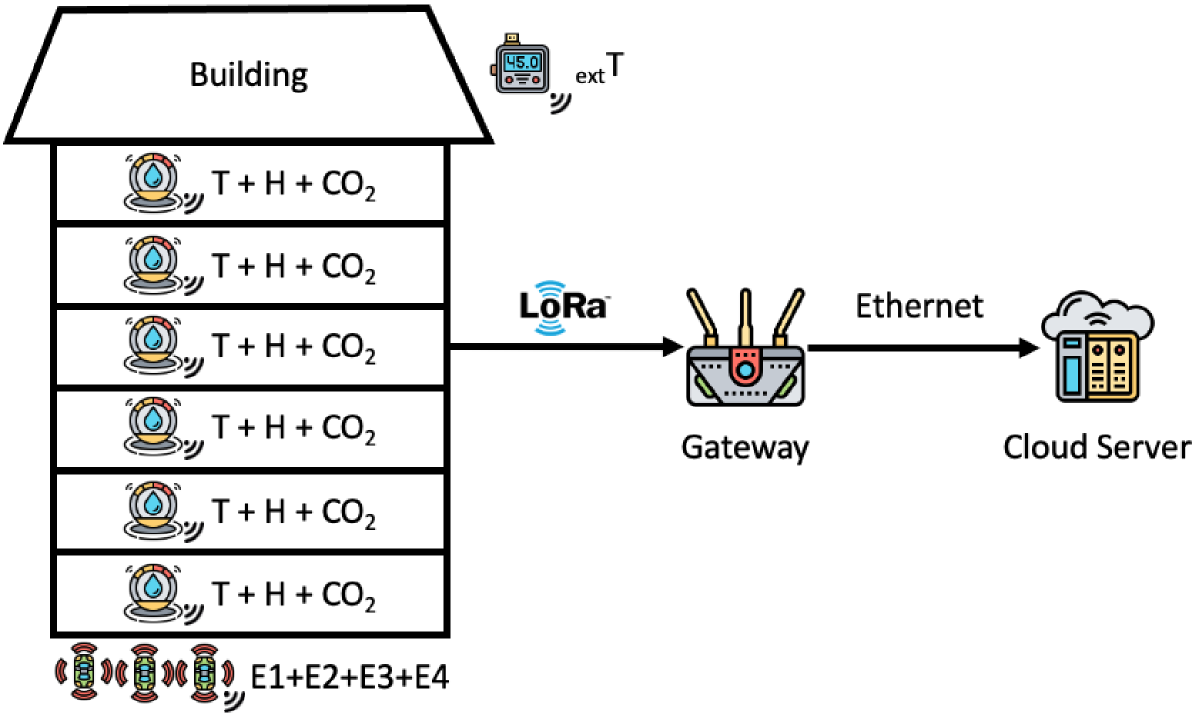

Figure 1. The architecture of the on-site component of the PRO-ENERGY system

At each building location, all installed smart sensors will be wirelessly connected to a LoRa (Long Range) Mesh Network, which will ensure 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. The gateway characteristics are presented in Table 1.

Table 1. Gateway Specifications

General Characteristics of Gateway	
Power Supply	24 VDC, ±20%, 20.0 W
Internal Flash Memory	At least 1MByte
Cloud server Communication	Ethernet Port
Operation temperature	-10~+75ºC
Degree of protection IEC/EN	IP20
Communication features LoRa	
LoRa	Mesh Network
Modulation	LoRa, GFSK, GMSK, BPSK
RF Output Power	Up to +20.8 dBm
Sensitivity	-116dBm(SF5), -121dBm(SF7), -136dBm(SF12)

As shown in Figure 1, three types of smart sensors will be employed. Overall, these sensors measure the following 8 quantities:

1. Indoor temperature
2. Indoor humidity
3. Indoor CO2
4. External temperature
5. Daily and monthly electricity consumption
6. KWH/m2
7. KWH for charging electric vehicles per month
8. KWH from Renewable Energy Sources (RES)

The sensors employed in the context of the PRO-ENERGY project are described in their respective sections presented below.

2.1.1. Sensor A - Temperature, Humidity and CO_2

All smart sensors of type A will be installed indoors in order to measure and report the internal temperature, humidity and CO_2 of a public building. Each sensor will employ its own Central Processing Unit (CPU) and will be responsible for digitizing the aforementioned measurements, performing digital processing (filtering) and quality control, and temporarily storing data at time intervals (time slots). Moreover, a series of mathematical processes will be performed based on the stored data in order to calculate the average, minimum and maximum values for each measured quantity. The characteristics of the type A sensor equipment is presented in Table 2.

Table 2. Specifications for Type A Sensor

General Characteristics of Type A Sensor (Temperature + Humidity + CO_2)	
Power Supply	24 VDC, ±20%, 1.5 W
Measuring range temperature	0...50°C
Measuring range humidity	0...100% r.H.
Measuring range CO_2	0...2000 ppm
Accuracy temperature	±0.5°C @ 25°C
Accuracy humidity	±3% between 20...80% r.H. @ 25°C
Accuracy CO_2	±50 ppm + 2% of measuring value
Degree of protection IEC/EN	IP20
Communication features	
LoRa	Mesh Network
Modulation	LoRa, GFSK, GMSK, BPSK
RF Output Power	Up to +20.8 dBm

At the end of the local data processing flow, the sensor sends to the Gateway all calculated values - "average", "maximum" and "minimum" for Temperature, Humidity and CO_2. Information is sent in the form of an “ASCII String” telegram. The exact communication protocol used by the sensor is described below.

Table 3. Gateway Communication Protocol of Type A Sensor

The string sent by the Type A Sensor to the Gateway has the following format:

#NodeID_TMax_TMin_TMv_HMax_HMin_HMv_Co2Max_ Co2Min_ Co2Mv _LRC(CR)

‘NodeID’ = 2 ASCII HEX Characters (8 bits BIN CODE) set to smart sensor

‘TMax’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Max Temp (0 to 100% of range)

‘TMin’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Min Temp (0 to 100% of range)

‘TMv’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Temp Mean Value (0 to 100% of range)

‘HMax’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Max Humidity (0 to 100% of range)

‘HMin’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time Slot Min Humidity (0 to 100% of range)

‘HMv’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Humidity Mean Value (0 to 100% of range)

‘Co2Max’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to Time Coot Max Co2 (0 to 100% of range)

‘Co2Min’ = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time Coat Min Co2 (0 to 100% of range)

'Co2Mv' = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Co2 Mean Value (0 to 100% of range)

'LRC (CR)' = Longitudinal Redundancy Check

2.1.2. Sensor B - External Temperature

Smart sensors of type B, will be installed outside each building in order to measure the external temperature. Each sensor of this type will have a CPU and handle the following: digitize the above measurements, perform digital processing (filtering) and quality control, and temporarily store data at time intervals (time slots). Some mathematical processing will also be conducted based on the stored data in order to calculate the average, minimum and maximum value of the external temperature. The characteristics of the type B sensor equipment is displayed in Table 4.

Table 4. Specifications for Type B Sensor

General Characteristics of Type B Sensor (External Temperature)	
Power Supply	24 VDC, ±20%, 1.5 W
Measuring range temperature	0...50°C
Accuracy temperature	±0.5°C @ 25°C
Degree of protection IEC/EN	IP65
Communication features	
LoRa	Mesh Network
Modulation	LoRa, GFSK, GMSK, BPSK
RF Output Power	Up to +20.8 dBm
Sensitivity	-116dBm(SF5), -121dBm(SF7), -136dBm(SF12)

After all data processing finishes, the sensor sends to the Gateway all calculated values (min, max and average) of the external temperature. Once more, all information is sent by the sensor in the form of an "ASCII String" telegram. The communication protocol employed is presented in Table 5.

Table 5. Gateway Communication Protocol of Type B Sensor

This string sent by the sensor to the Gateway has the following format: #NodeID_TMax_TMin_TMv_HMax_HMin_HMv_Co2Max_ Co2Min_ Co2Mv _LRC(CR) *'NodeID' = 2 ASCII HEX Characters (8 bits BIN CODE) set to smart sensor* *'TMax' = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Max Temp (0 to 100% of range)* *'TMin' = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Min Temp (0 to 100% of range)* *'TMv' = 2 ASCII HEX Characters (8 bits BIN CODE) corresponding to the Time slot Temp Mean Value (0 to 100% of range)* *'LRC(CR)' = Longitudinal Redundancy Check*

2.1.3. Sensor C - Energy Consumption

Type C smart sensors will be installed at each building electricity board and be able to measure the following:

- E1. Daily and monthly electricity consumption
- E2. Electricity per M2 of space
- E3. Electricity for charging electric vehicles per month
- E4. Electricity from RES

Similar to the other sensors, each sensor will employ its own Central Processing Unit (CPU) and will be responsible for digitizing the aforementioned measurements, performing digital processing (filtering) and quality control, and temporarily storing data at time intervals (time slots). Moreover, a series of mathematical processes will be performed based on the stored data in order to calculate the average, minimum and maximum values for each measured quantity. The characteristics of the type C sensor equipment is presented in Table 6.

Table 6. Specifications for Type C Sensor

General Characteristics of Type C Sensor (Energy Consumption)	
Power Supply	24 VDC, ±20%, 1.5 W + 3 X 400 VAC
Measuring	Active Energy
Max Current	63A
Accuracy temperature	±1%
Degree of protection IEC/EN	IP20
Communication features	
LoRa	Mesh Network
Modulation	LoRa, GFSK, GMSK, BPSK
RF Output Power	Up to +20.8 dBm
Sensitivity	-116dBm(SF5), -121dBm(SF7), -136dBm(SF12)

Following all data processing, a type C sensor sends to the Gateway all calculated values. Information is sent in the form of an “ASCII String” telegram, similar to the method employed by the other two sensor types. The communication protocol used by the type C sensors is presented in Table 7.

Table 7. Gateway Communication Protocol of Type C Sensor

This string sent by the sensor to the Gateway has the following format: #NodeID_E1_E2_E3_E4 _LRC (CR) *'NodeID' = 2 ASCII HEX Characters (8 bits BIN CODE) set to smart sensor* *'E1' = 8 ASCII HEX Characters (32 bits BIN CODE) corresponding to the value of E1 in KWh* *'E2' = 8 ASCII HEX Characters (32 bits BIN CODE) corresponding to the value of E2 in KWh* *'E3' = 8 ASCII HEX Characters (32 bits BIN CODE) corresponding to the value of E3 in KWh* *'E4' = 8 ASCII HEX Characters (32 bits BIN CODE) corresponding to the value of E4 in KWh* *'LRC (CR)' = Longitudinal Redundancy Check*

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.

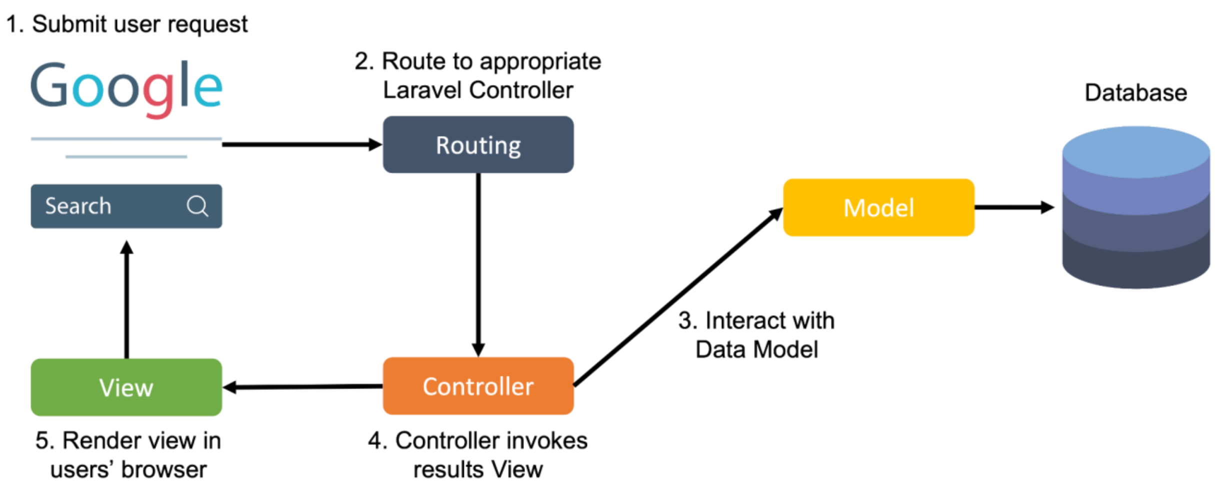

Figure 2. The architecture of the off-site component of the PRO-ENERGY system

The PRO-ENERGY Joint ICT platform application will be 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.

All application code will reside in an online code repository. More specifically, GitLab will be used as a version control system. All commits will be archived and accessible for all project members.

The Joint ICT platform will be connected to the PRO-ENERGY project website as well as the websites of other project partners. It will also bear 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 will revolve around the following list of views planned to be implemented:

- Login
- Logout
- Password Reset
- User Management
- Buildings (Homepage)
- History
- Recommendations
- About the Project
- User Account
- Contact.

2.3. Mockups

A mockup is regarded as a static visual representation of a product design. Mockups often fall between wireframes and prototypes, which may include more detail than wireframes. Still, a low-fidelity mockup is often intentionally basic so that the project team can focus on design and flow rather than intricate details. Low-fidelity mockups are generally considered to be valuable in software engineering projects since they provide numerous advantages. These include saving time and resources during product development, receiving early feedback from stakeholders and iterating on the initial design, and improving cross-functional relationships by conveying key ideas among the project team members.

The figures presented in this section reveal the high-level view for some graphical user interfaces, which include the login screen (Figure 3) along with the Buildings (Figures 4 & 5) and Recommendations panel (Figure 6).

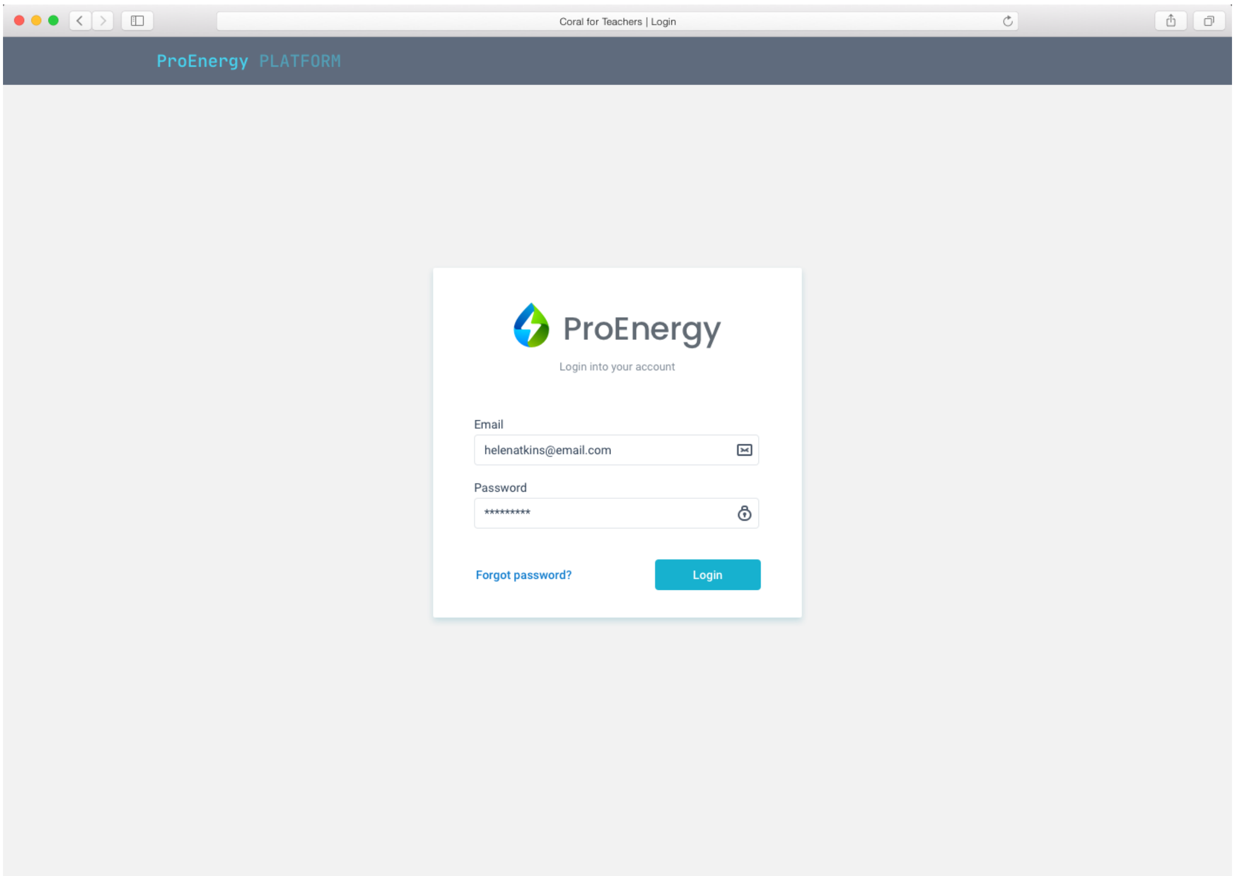

Figure 3. A representation of the login screen of the PRO-ENERGY web application

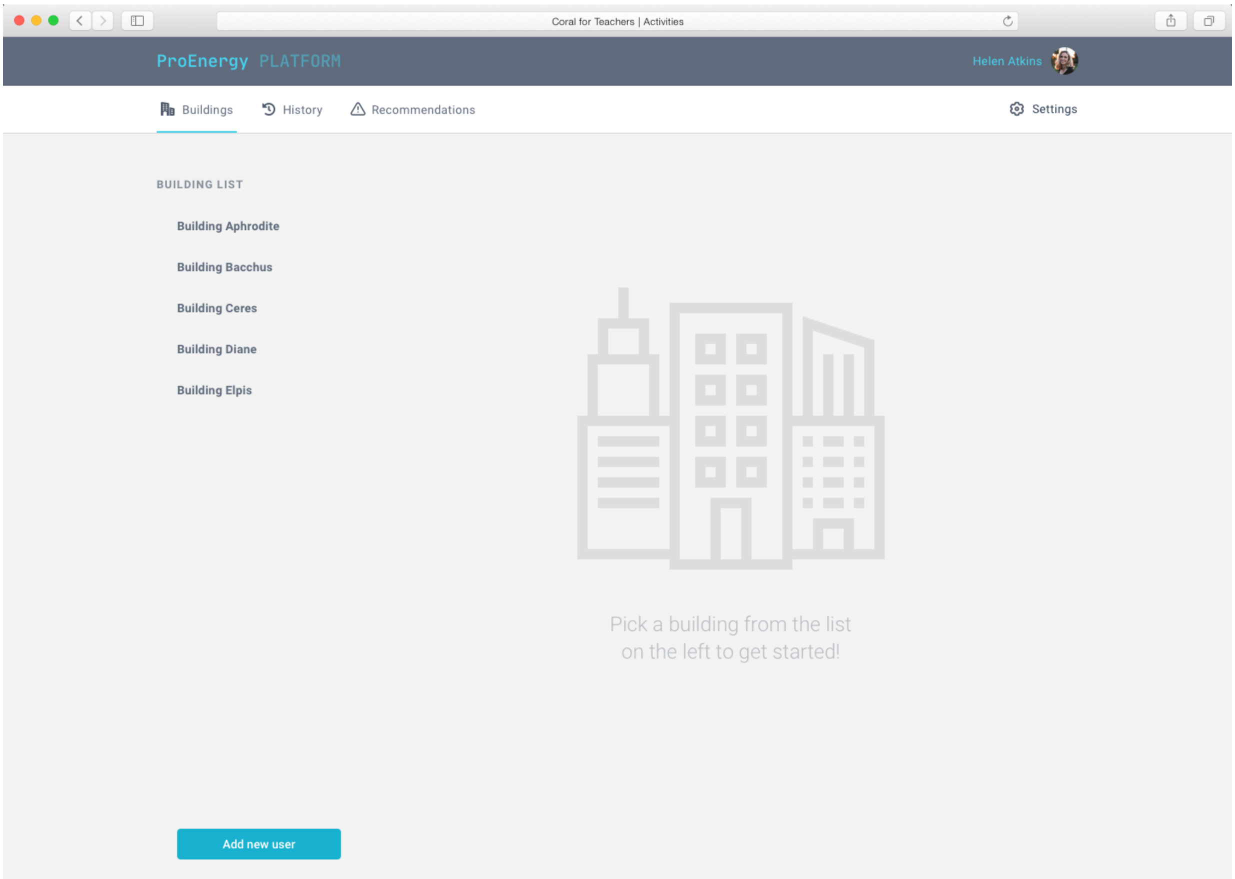

Figure 4. A representation of the view that follows the login of a super-admin

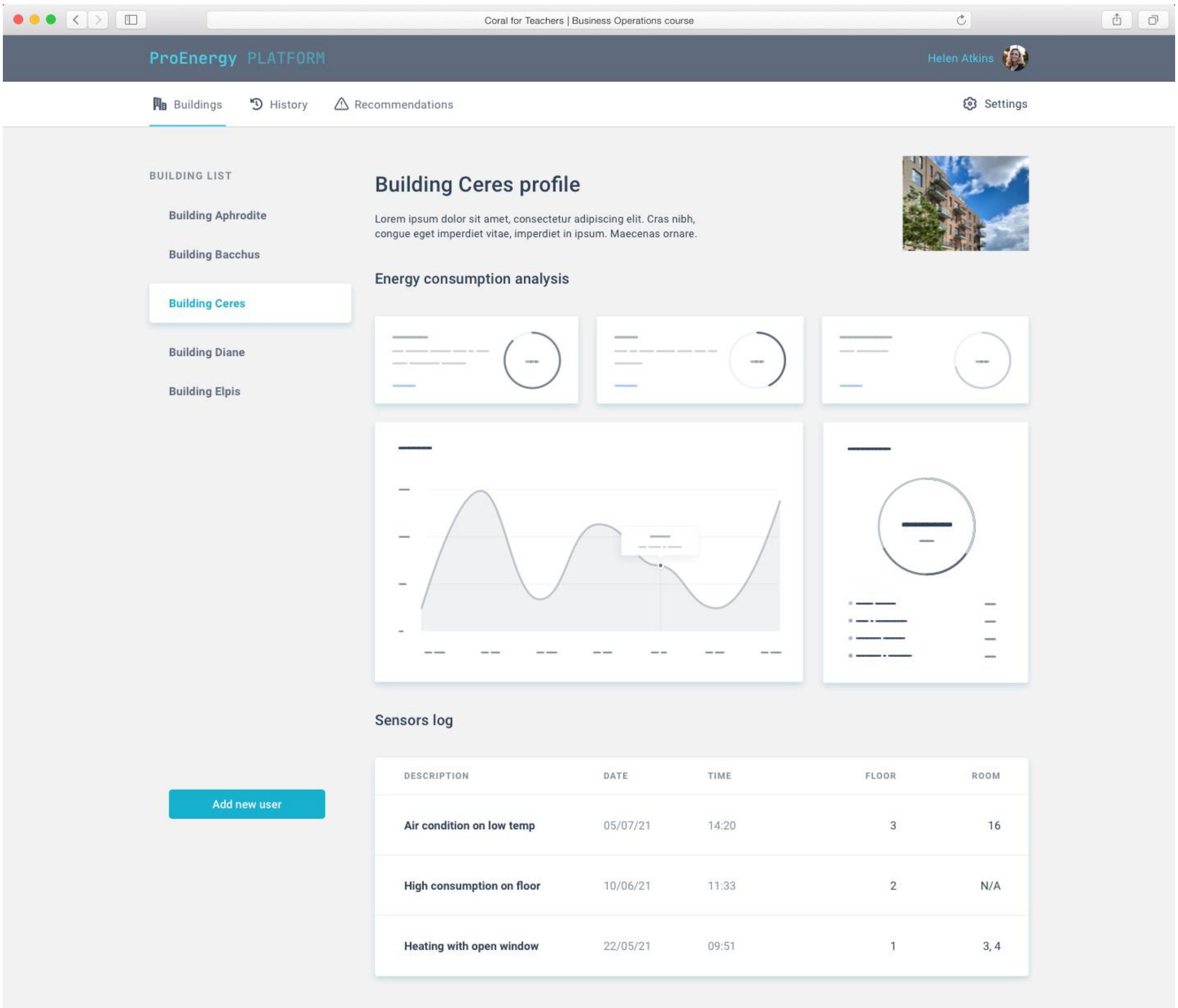

Figure 5. A representation of the view that displays information about the energy consumption of a public building

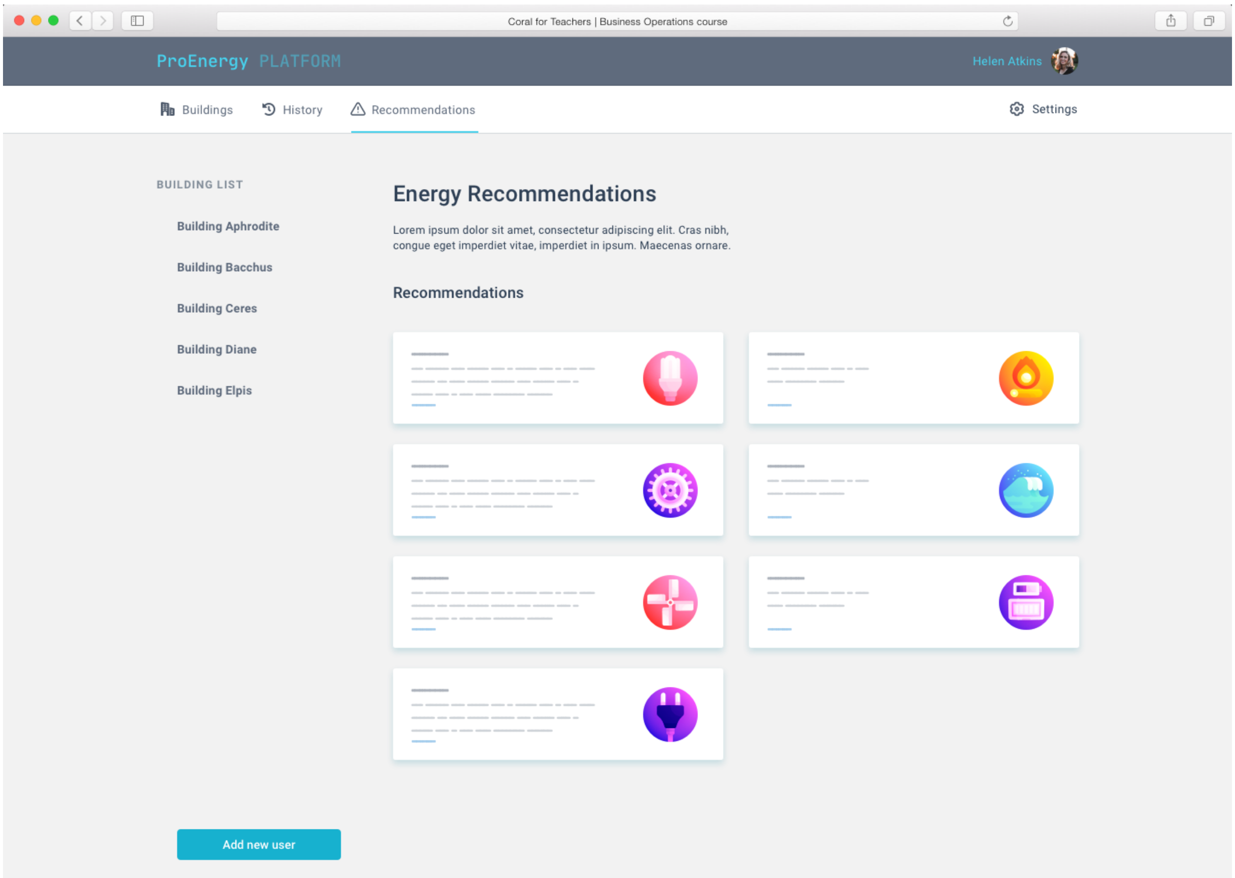

Figure 6. A representation of the view that displays recommendations aiming to improve energy saving in a public building

2.4. 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. SPECIFICATIONS

3.1. Authentication

3.1.1. Description

Authentication is the process of determining whether someone or something is, in fact, who or what it declares itself to be. Authentication technology provides access control for systems by checking to see if a user's credentials match the credentials in a database of authorized users or in a data authentication server.

Users are usually identified with a user ID, and authentication is accomplished when the user provides a credential, for example, a password, that matches that user ID. Most users are most familiar with using a password, which, as a piece of information that should be known only to the user, is called a knowledge authentication factor. Adding authentication factors to the authentication process typically improves security. Strong authentication usually refers to authentication that uses at least two factors, where those factors are of different types.

Due to the nature of the HTTP and HTTPS web application protocols, which are stateless, strict authentication would require end-users to re-authenticate every time they access a system resource. Rather than burden end-users with that process for each interaction over the web, protected systems often rely on token-based authentication, in which authentication is performed once at the start of a session. The authenticating system issues a signed authentication token to the end-user application, and that token is appended to every request from the client.

Entity authentication for systems and processes can be carried out using machine credentials that work like a user's ID and password, except the credentials, are submitted automatically by the device in question. They may also use digital certificates that were issued and verified by a certificate authority as part of a public key infrastructure to authenticate an identity while exchanging information over the internet.

3.1.2. Use case

A user accesses the PRO-ENERGY joint ICT platform domain. In case the user is not logged in, to be able to access the platform information, the user is requested to be authenticated. For that purpose, the user is asked to enter their username and password.

The credentials provided by the user are compared to those in the system database of authorized users' information through an authentication server. If the credentials match, the user is subjected to the two-factor authentication process, which adds an extra layer of protection to the process of authentication. 2FA requires that a user provide a second authentication factor in addition to the password. 2FA systems require the user to enter a verification code generated by an authentication application that is installed on a pre-registered mobile phone.

Once all user input is assessed as valid and correct by the system, the authentication process is followed by an authorization process in order to determine whether the authenticated entity should be permitted access to a protected resource or module.

3.2. Authorisation

3.2.1. Description

Authorization in system security is the process of giving the user permission to access a specific resource or function. This term is often used interchangeably with access control or client privilege. Giving someone permission to access a particular resource on a cloud server or providing individual users with administrative access to an application are common examples of authorization.

In secure environments, such as the PRO-ENERGY system, authorization must always follow authentication. Users should first prove that their identities are genuine before an authentication module can grant them access to the requested resources. Systems and processes may also need to authorize their automated actions. For instance, online backup services, patching and updating systems and remote monitoring systems, such as those often used in building energy management systems, need to be securely authorized to be involved in an interaction with the system.

3.2.2. Use case

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.

3.3. Users Administration

3.3.1. Description

User administration solves the problem of managing user access to various resources. Typically, a user administration module enables the system administrator to manage all individuals who can access the system by adding/registering them as users in the system. An administrator can often create user groups, and assign users to them. Use roles specify what different users and user groups can access as well as what types of actions they can perform.

3.3.2. Use case

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.

3.4. Building Overview

3.4.1. Description

Monitoring the energy and other needs in buildings efficiently and intelligently can have considerable benefits. The PRO-ENERGY system provides an intuitive and practical way of monitoring and managing properly the energy consumption of buildings operating in the public sector. This can serve as an important tool for understanding the electricity needs and consumption profile of those public buildings, so as to more effectively manage their energy consumption. The ultimate objective is to help staff consume only the energy required to meet their work needs, leading to an overall decreased energy cost.

3.4.2. Use case

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 (Figure 5). 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 Table 8.

Table 8. A set of metrics calculated and displayed in the PRO-ENERGY web application

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)

3.5. Recommendation Engine

3.5.1. Description

Recommender systems have significantly developed in recent years in parallel with the witnessed advancements in the Internet of Things (IoT) for the energy-saving domain. The particular systems combine the data gathered from smart sensors and human decision-making analytics, to implement powerful behavioural change support systems, in which recommendations could be easily embedded into daily behaviours to reach an effective energy-saving level.

3.5.2. Use Case

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 Table 9.

Table 9. Indicative rules leveraged by the PRO-ENERGY system to provide recommendations

Condition	Recommendation
When the indoor temperature exceeds 23°C while heating is enabled	Reduce heating
When the indoor temperature is under 24°C while cooling is enabled	Reduce cooling
When CO_2 exceeds 600ppm	Ventilate the building
When the A/C system is enabled	The A/C system should be active only while the windows are closed

When the Heating system is enabled	Heating should be active only while the windows are closed
When the building is not in use (for instance, when it is closed during holidays)	Turn off all lights
When energy production from Renewable Energy Sources (RES) is below a predefined threshold	0% energy: Install a RES system; Below 10% energy: Significantly increase RES; Below 50% energy: Increase RES usage; (Ultimate goal: 100% from RES)

Apart from the above recommendations, whenever the system detects an important issue that leads to significant energy waste repeatedly in a specific public building, it may display an additional tip/recommendation for performing a particular energy-saving upgrade. The below list includes a set of such recommendations:

- Renovation of exterior walls with insulation
- Renovation of the roof with insulation
- Installation of thermal insulation frames
- Installation of solar shading systems
- Replacement of pump or heating system with a more energy-efficient one
- Installation of thermostatic valves
- Replacement of lights with LED
- Installation of Energy Saving Switches and Presence Sensors
- Installation of BMS smart meters
- Installation of a photovoltaic system
- Installation of solar thermal system
- Replacement of electric boilers with heat pumps
- Installation of a building automation system (automatic central control heating, ventilation and air conditioning of a building, lighting, etc.)
- Change in end-user behaviour: status control devices standby (screens, computers, laboratory equipment, lights, etc.)

3.6. History

3.6.1. Description

Historical data are crucial in the energy-saving domain as they depict the energy usage footprint over time which in turn can help draw conclusions about the effectiveness of a recommendations system. Storing historical data enables the detection of energy consumption patterns and their underlying context, which can be useful in order to develop more rule-based recommendations or alternatively fine-tune the existing ones.

3.6.2. Use Case

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.

3.7. Localisation

3.7.1. Description

Language localisation is regarded as the process of adapting a product or service to meet the needs of a particular language, culture or desired population's "look-and-feel". Based on the project needs, the system deliverable is expected to support the following languages: Greek, English, Bulgarian and Albanian.

A successfully localized service or product is one that appears to have been developed within the local culture. In addition to idiomatic language translation, such details as time zones, money, national holidays, local colour sensitivities, product or service name translation, gender roles and geographic references must all be considered.

High localization costs are often incurred when a localization process is not run effectively. Establishing localization guidelines can increase the quality, accuracy, and user-friendliness of the international product version. This is why the initial product specifications should take into account localization as part of the product cycle. Delaying localization to the end of the cycle can delay the shipping date because of any unexpected localization problems that require code changes. For instance, localizability testing should start once the product functionality is stable. Figure 7 below shows an indicative timeline for achieving product localization in the context of the PRO-ENERGY project.

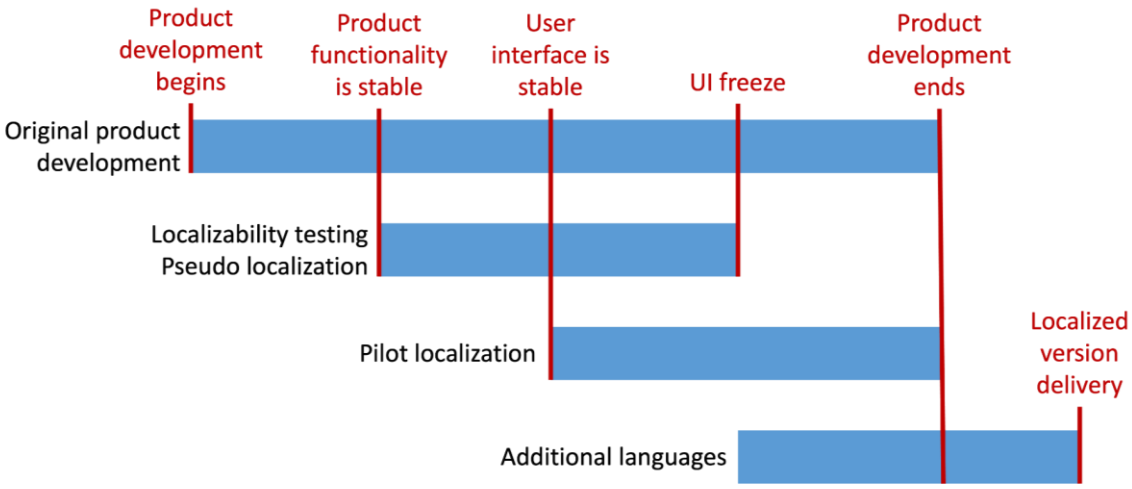

Figure 7. The timeline for achieving localization in the PRO-ENERGY web application

From a language standpoint, avoiding grammar and spelling mistakes in the original software text reduces the localization team's workload when those mistakes are corrected. Corrections will show up as a change to the localization team and will therefore need to be fixed again in the localized version. For the same reason, avoiding cosmetic changes in the content that do not add value to the meaning will speed up localization.

3.7.2. Use case

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.

4. OTHER REQUIREMENTS

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

4.2. 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 being developed will adopt a series of open architecture principles in order to allow its continuous improvement and smooth expansion, without disrupting its operation.

4.3. General Data Protection Regulation (GDPR)

Throughout the system development life cycle, a “privacy-by-design” approach will be employed in an attempt to provide users with the highest level of security and privacy. The web application that will be developed will be fully GDPR compliant. This will be achieved by making privacy and security an integral part of software product development, starting with key architectural decisions. In this fashion, the project software will be 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, will only be processed when there is a lawful basis for processing, e.g. consent, contract, legal obligation. Furthermore, all data should be processed in a manner that ensures security and protection against unlawful processing, accidental loss and damage.

4.4. Accuracy and Validity

The system will employ 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

4.5. Timing and Capacity

The system is intended to be 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 will 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 will be reviewed and once the initial development is complete the system will be deployed and hosted on the most appropriate cloud server infrastructure.

4.6. 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.

4.7. Usability

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

4.8. Failure Contingencies

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

4.9. Security

The system will be developed under the leadership of TREK Development, using industry-standard web development tools and practices. TREK Development commits to developing the initial system, as described in this document, 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.

4.9.1. 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 utilizes 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.

4.9.2. Server Security

Any server on a public network can become the target of hackers. Thus, ensuring system security is 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 will ensure 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 will be taken while configuring and setting up the PRO-ENERGY server infrastructure. This will serve as a solid starting point, allowing overtime to build an even more tailored security approach that suits the project needs.

- **SSH Keys.** Through the utilization 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.

APPENDIX I: LRC Generation Process

General Symbols:

’= Beginning of the command.

‘_’ = Space.

(CR) = asc (13).

‘LRC’ = 8 – bit (2 ASCII characters) Longitudinal Redundancy Check.

It is sent at the end of the "string".

The "high-order character" is sent first, followed by "low-order character".

The process to build the "LRC" is:

1. Add (without holder) all the "bytes" of the "string" without the ‘#’, the ‘_’, the LRC and the (CR)
2. Subtract the final result (one byte long) from 255, and add 1 to convert it to a complement of 2.

An example of a LRC Generation Function (returns the LRC as a type char):

```
char LRC(char *auchMsg, short usDataLen)
{
   char   *auchMsg;                /* message to calculate LRC upon */
   short usDataLen;                /* quantity of bytes in message */
   char    uchLRC = 0;             /* LRC char initialized */
   while(usDataLen >  0) {
       /* add buffer byte without carry */
       If ((*auchMsg != 35) && (*auchMsg != 32))
          uchLRC += *auchMsg;
          auchMsg++;
       usDataLen--;
    }
    return ((~uchLRC)+1);
}
```

APPENDIX II: ABBREVIATIONS AND DEFINITIONS

API: Application Programming Interface, a set of protocols or standards for communicating with web-based applications

RESTful API: An API that uses a standard set of HTTP request

Laravel: An open-source PHP web framework, based on Symfony and intended for the development of applications following the model–view–controller architectural pattern

LRC: Longitudinal redundancy check

CO_2: Carbon dioxide

RES: Renewable energy sources

KWH: A kilowatt-hour (kWh) is a measure of energy

ICT: Information and Communication Technology

MySQL: Open-source database management system

PHP: General-purpose scripting language especially suited to web development

HTML: HyperText Markup Language; the standard markup language for documents designed to be displayed in a web browser

CSS3: Cascading Style Sheets; the language used to describe the presentation of a document written in a markup language

LoRa: A proprietary low-power wide-area network modulation technique, which is based on spread-spectrum modulation techniques derived from the chirp spread spectrum technology

Mesh Network: A wireless communications network made up of radio nodes organized in a mesh topology

LRC: In telecommunication, a longitudinal redundancy check (LRC) is a form of redundancy check that is applied independently to each of a parallel group of bit streams

CR: The Carriage Return (CR) character (0x0D , \r)

ASCII: abbreviated from American Standard Code for Information Interchange, is a character encoding standard for electronic communication