UNIVERSIDAD DE GUADALAJARA

CENTRO UNIVERSITARIO DE LOS VALLES

UNIVERSIDAD DE GUADALAJARA

Red Universitaria e Institución Benemérita de Jalisco

Software Configuration Management

Omar Ali Zatarain Durán

Salvador Curiel Hernández

208260648

December 1st, 2023

Index

Contenido

Preamble

This document, developed within the scope of the "Software Configuration Management" course, signifies the culmination of a semester-long journey in the design and development of the "Smart Energy Management System for Public Buildings" project. Throughout this process, we have explored diverse areas, ranging from context and policies to requirements, analysis, and system design. This document stands as the final synthesis, incorporating the most recent and updated versions of prior documents. It serves as a comprehensive reference covering all essential aspects for the conception and realization of an innovative system aimed at optimizing energy consumption in public buildings.

Software Configuration Management

This section delves into the essential practice of software configuration management, a comprehensive process for controlling and tracking project elements throughout their lifecycle. From the identification and recording of elements to change and version management, configuration management ensures the consistency and integrity of the software, fostering an organized and controlled development environment. This section introduces the key principles of this discipline, emphasizing its significance for effective project development and collaboration among team members.

Introduction

This document marks the complete journey from the inception to the culmination of the "Smart Energy Management System for Public Buildings" [1] project. Throughout its development, various documents have been generated, addressing crucial aspects ranging from the initial context to requirements, detailed analysis, and system design. These documents, though subject to iterations and changes as the project evolved, have been consolidated in this final compilation, presenting the most current versions.

Each stage of the project has been meticulously documented, and all versions are available in a GitHub repository [2]. This not only facilitates a historical understanding of the project but also allows for a detailed analysis of the evolution of each component and decision made during its development.

In the course of this narrative, we will delve into the selected project, the "Smart Energy Management System for Public Buildings." Four new requirements have been incorporated, analyzed thoroughly in terms of time, financial, human resources, and effort. Decisions made based on this analysis provide a clear insight into the strategic direction and practical considerations that have guided each phase of the project. Therefore, this document is not only a comprehensive compendium but also a testament to the informed decision-making that has shaped the project as a whole.

Ultimately, this document invites exploration into the complexity and evolution of a project that has challenged and stimulated our approach to energy management in public buildings, reflecting not only the decisions but also the constant learning that has been an integral part of this journey.

Configuration Identification

Configuration identification is a pivotal aspect of the project's management, encompassing the systematic identification and labeling of all project components, from software and hardware to documentation. This process ensures that each element is uniquely distinguished, allowing for precise tracking and control throughout the project's lifecycle. By assigning distinct identifiers to various configurations, such as versions, releases, or iterations, the project team can effectively manage changes, monitor progress, and trace the evolution of individual components. Configuration identification lays the foundation for robust version control, facilitating collaboration among team members and providing clarity in navigating the intricate landscape of the project's configurations. This meticulous process is instrumental in mitigating risks associated with configuration-related issues and ensuring a well-organized and streamlined development process.

Baseline

The Baseline 1.0 [3] document serves as the project's cornerstone, comprehensively addressing the project's vision, requirements (both functional and non-functional), detailed analysis of these requirements, and the projected scope. Additionally, this pivotal document not only provides a clear overview of the proposed system's structure and functionality but also incorporates design elements, such as use case diagrams. This wealth of information lays the groundwork for the project's subsequent development, offering a cohesive and strategic guide that addresses both technical and conceptual aspects. The forthcoming presentation will provide a concise yet informative journey, highlighting key elements that propelled the project's evolution from its early stages.

Baseline 1.0

Description

This project aims to develop an intelligent system designed to enhance energy efficiency in public buildings. Leveraging modern technologies, our objective is not only to curtail operational expenses but also to diminish our environmental footprint while fostering ecological habits. Our vision encompasses the creation of an infrastructure that not only meets current demands but also lays the groundwork for a more sustainable future. The integration of advanced technological solutions will enable us to efficiently manage lighting, climate control, and other crucial aspects, dynamically responding to occupancy conditions and environmental status. This comprehensive approach not only seeks to optimize energy performance but also actively contributes to the establishment of more sustainable and eco-conscious environments.

Requeriments

Functional requeriments

- **Ensure Energy Efficiency:** Attain a significant reduction in overall energy consumption by optimization.
- **Real-time Monitoring:** Supervise energy consumption in specific areas of the buildings.
- **Smart Automation:** Automatically control things like lights and climate based on occupancy and conditions.
- **Data Analysis:** Provide analysis to identify consumption patterns and trends.
- **Inefficiency Detection:** Detect issues like unnecessarily lit lights or faulty equipment.
- **Renewable Energy Integration:** Allow the incorporation of sustainable energy sources.
- **Additional remote server:** The client requests an additional master remote server for getting reports of usage for several buildings in different cities, it includes a module in your original project that connects to the remote server.
- **State of the components:** due to the new characteristics of sensors and actuators, the client requests a more interoperable architecture that records the internal state of each component. Statuses range from operable, off, broken, and running.
- **Automatic reports:** Due to a new ecological standard, every system must report the energy efficiency of the monthly operation of the system.
- **Customization:** the system must include screen customization according to the needs of the company's image, including screen color, logo configuration and addition/deletion.

Non-functional requirements

- **Minimal Latency:** Ensure a maximum response time of 3 seconds in real-time monitoring and control.
- **Intuitive Interface:** Offer a user-friendly interface for users of varying skill levels.
- **Data Security:** Ensure the protection of consumption and control data with robust security measures.
- **Continuous Availability:** Keep your system up and running 24 hours a day.

Key benefits

- Reduction of energy consumption and operational costs.
- Contribution to a more sustainable and eco-friendly Environment.

Requirements Analysis

The objective of this document is to provide a detailed description of the functional and non-functional requirements for the "Smart Energy Solution for Public Buildings" project. It serves as a fundamental resource to guide the design, development, and implementation of the energy management system.

Project Scope

The scope of this project encompasses the creation of a comprehensive energy management system for public buildings, enabling energy consumption optimization, real-time monitoring, intelligent automation, and the integration of renewable energy sources. This system is designed to enhance energy efficiency and reduce operational costs for public buildings.

Definitions and Acronyms

Energy Efficiency: The ability to use energy more efficiently to achieve the same results or services.

Real-time Monitoring: The capability to continuously supervise energy consumption and other resources with up-to-date information.

Intelligent Automation: The automation of devices and systems based on real-time data and predefined conditions.

Renewable Energy Management: The incorporation of sustainable and renewable energy sources, such as solar panels or wind turbines, into a building's energy system.

Desing of system

The following diagrams showcase some of the key interactions and functions of the energy management in the project. These diagrams provide a general overview of how the system interacts with the actors to carry out essential tasks in energy management.

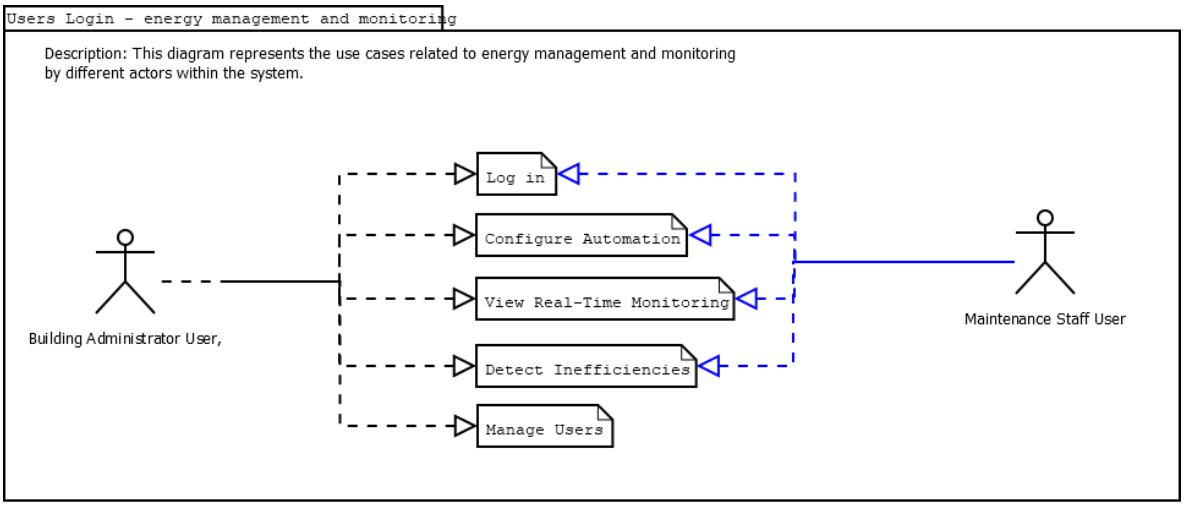

Image 1 - Energy and monitoring use case diagram.

Use Cases:

- **Log In:** Allows users to log in to the system.
- **Configure Automation:** Allows the administrator user to configure lighting and climate automation.
- **View Real-Time Monitoring:** Allows users to view real-time monitoring of energy consumption.
- **Detect Inefficiencies:** Allows users to report and manage energy inefficiencies.
- **Generate Reports:** Allows users to generate energy consumption reports.
- **Manage Users:** Allows the administrator user to manage user accounts and permissions.

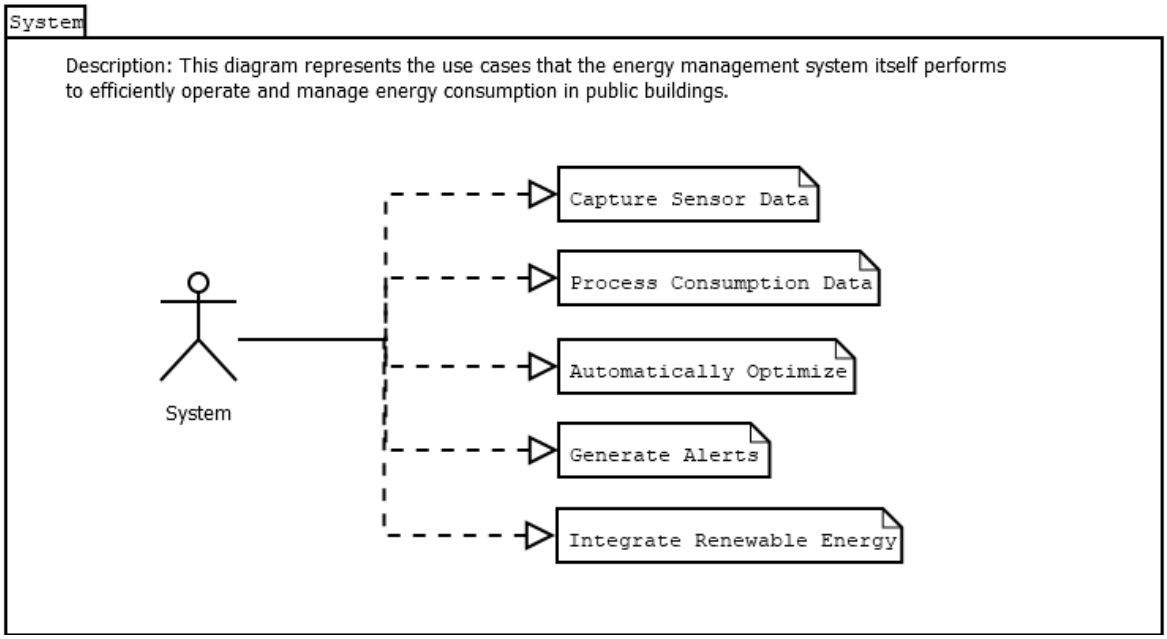

Image 2 - System use case diagram.

Use Cases:

- **Capture Sensor Data:** Allows the system to capture data from energy consumption sensors.
- **Process Consumption Data:** The system processes consumption data for analysis.
- **Automatically Optimize:** The system makes automatic adjustments based on data and optimization algorithms.
- **Generate Alerts:** The system generates alerts in case of inefficiencies or abnormal situations.
- **Integrate Renewable Energy:** Allows the system to integrate energy from renewable sources when available.

Configuration Control:

Configuration control is a critical phase in software configuration management responsible for overseeing and managing changes to configurable project elements. This section delves into the significance of configuration control in maintaining the integrity and consistency of the software as it evolves. Methods for assessing and approving changes are explored, ensuring that only authorized modifications are implemented. This process contributes to the stability and quality of the software during its development and maintenance.

Policies

In this segment, the previously crafted policies are incorporated to guide the development and execution of the project. These policies serve as a regulatory framework, establishing clear guidelines for operations, conduct, and decision-making within the project's environment. Their integration ensures consistent coherence and alignment with ethical principles, quality standards, and responsibility throughout all project phases. This set of policies provides a robust foundation to steer the actions of the project team, ensuring efficiency and effectiveness in achieving project objectives.

Policies

Company Policies

This document presents the Policies [4] of "***InnovateTech Solutions***". These policies establish fundamental guidelines and standards that govern our operations and conduct in the business environment. They represent our commitment to ethics, quality, and responsibility in all our activities and business relationships.

Committee Structure

Below, we introduce the committee members who play key roles in strategic decision-making and project leadership. Each of them brings their expertise and leadership to ensure the success of our initiative.

- CEO
- Project Manager
- Director of Human Resources
- Director of Finance
- Systems Engineer
- Development Leader

Functions and Responsibilities

CEO:

- Establish the project's strategic vision.
- Make key decisions and provide executive leadership.
- Represent the project to external parties and clients.
- Align the project with organizational goals.
- Oversee the implementation of strategies for project success.
- Evaluate and mitigate executive-level risks.

Project Manager:

- Plan, coordinate, and supervise all project activities.
- Allocate resources and manage the schedule.
- Regularly report on progress and issues.
- Achieve project objectives within timelines and budgets.
- Coordinate communication among team members and stakeholders.
- Identify and mitigate project risks.

Director of Human Resources:

- Manage talent acquisition and development for the project.
- Handle conflicts and promote a positive work environment.
- Ensure effective and motivated staffing.
- Manage aspects related to well-being and performance management.

Director of Finance:

- Oversee the budget and financial aspects of the project.
- Conduct financial analysis and provide reports to senior management.
- Ensure efficient use of financial resources.
- Report on the project's financial status and recommend adjustments as needed.

Systems Engineer:

- Design the technical architecture of the system.
- Oversee the implementation and maintenance of the system.
- Ensure the technical infrastructure supports project objectives.
- Collaborate with other teams to ensure system integration and efficiency.

Development Lead:

- Lead and supervise the software development team.
- Ensure quality and timely delivery of products.
- Develop and maintain coding standards.

- Collaborate with other leaders to integrate development with the rest of the project.

Junior Programmer:

- New to programming, requires supervision.
- Performs simple tasks and learns technical skills.

Mid-Level Programmer:

- Experienced in real projects.
- Works more independently, contributes to technical decisions.

Senior Programmer:

- Extensive experience, expert in technologies.
- Leads projects, makes architectural decisions, mentors and others.

Decision-Making Scales

This module is a vital resource for classifying and managing decisions effectively in an organization. It provides a decision scale from low impact to urgent, aiding leaders and teams in making better decisions.

- **Low** (10%)**:** Decisions of low impact that do not significantly affect short-term goals or outcomes. They can be handled routinely or scheduled for later review.
- **Medium** (30%)**:** Decisions that affect important aspects of operations or outcomes but do not require immediate action. They should be planned and managed effectively.
- **High** (40%)**:** Critical decisions with a significant impact on company objectives that require priority attention. Careful evaluation is needed before decision-making.
- **Urgent** (50%): Decisions that require immediate action due to their immediate impact on the company or their ability to prevent serious issues. They should be addressed without delay.

Decision-Making Process Module

The decision-making process consists of several interconnected steps that guide individuals and teams in selecting the best option among various alternatives. These steps include:

Decision-Making Process:

1. **Problem Identification:**
    - **Description:** The Project Manager clearly identifies the problem or decision that needs to be made, in consultation with the team and other relevant members.
2. **Information Gathering:**
    - **Description:** The Director of Human Resources and Systems Engineer is responsible for gathering relevant data and facts to help understand the problem and available options, in collaboration with relevant teams.
3. **Alternative Analysis:**
    - **Description:** The Development Leader works closely with the Project Manager to develop a list of possible solutions or courses of action, and subsequently evaluate their advantages and disadvantages.
4. **Consequence Evaluation:**
    - **Description:** The Director of Finance and the CEO collaborate to consider the potential consequences of each alternative in terms of costs, benefits, risks, and opportunities.
5. **Decision-Making:**
    - **Description:** The CEO and the Executive Committee selects the alternative that best aligns with the organization's objectives and values, based on the information provided by the responsible parties.

Evaluation Scale:

This general scale reflects the relationship between initial estimates and actual results for each of the four categories: time, money, effort, and human resources.

- **0-10% -** Very close to the estimate.
- **11-15% -** Slightly below the estimate.
- **16-20% -** Moderately below the estimate.
- **>21% -** Deviated significantly from the estimate.

Evaluation Process

Upon completion of the project, we will conduct a review to compare the initial estimates with the actual results in terms of time, money, effort, and human resources. This process will unfold as follows:

1. Data Compilation:
    - Detailed data will be gathered on time invested, actual costs, dedicated effort, and the utilization of human resources during the project.
2. Application of Measurement Scales:
    - Specific measurement scales will be employed to assess accuracy in each area: time, money, effort, and human resources.
3. Documentation of Differences:
    - Detailed documentation will outline the reasons behind any significant differences between initial estimates and actual results.
4. Analysis and Interpretation:
    - A thorough analysis of the collected data will be conducted to interpret the project's performance in terms of our initial estimates.
5. Identification of Improvements:
    - Findings from the review will be used to pinpoint areas for improvement in our estimation and planning skills.
6. Implementation of Adjustments:
    - Strategies and estimation processes will be adjusted based on lessons learned, aiming to enhance future projects.

Auditing

Auditing in the realm of software configuration management involves the systematic review and assessment of configuration-related processes and activities. Records, documents, and procedures are scrutinized to ensure compliance with established standards and requirements. This section underscores the significance of regular audits in identifying potential deviations, enhancing process efficiency, and maintaining software quality.

Context

In this segment, the integration of the "Context" [5] document will be addressed. This document encapsulates the project's initial setting, outlining the initial human resources required for project development, including the project team, associated salaries, estimated development time, and overall project cost. Simultaneously, it delves into the rationale behind the incorporation of new requirements, providing an insightful exploration of the implications these additions carry. The "Context" document functions as a vital reference for decision-making, offering a holistic perspective on the project's landscape and aiding in the assessment of whether the inclusion of new requirements aligns with the project's overarching goals. The ensuing amalgamation will weave together key insights

from both the "Baseline 1.0" and "Context" documents, providing a consolidated view of the project's inception, resource allocation, and strategic considerations.

Context

Modules

1. **Real-time Energy Monitoring:** This module enables constant monitoring of energy consumption in different areas of the building and provides real-time data.
2. **Intelligent Automation:** This module allows for the automation of systems such as lighting, HVAC, and ventilation based on occupancy and environmental conditions to optimize energy efficiency.
3. **Load Management:** It controls the electrical load of devices and systems to prevent demand spikes and reduce energy costs.
4. **Inefficiency Detection:** Utilizes sensors and algorithms to detect energy inefficiencies, such as unnecessary lights or faulty equipment.
5. **Reporting and Analysis Generation:** This module collects consumption data and generates reports and analyses to identify patterns, trends, and improvement opportunities.
6. **User Management:** Manages user accounts and permissions to ensure that only authorized personnel can access and make changes to the system.
7. **Alarm and Notification Management:** Configures automatic alarms and notifications in case of critical events or detected inefficiencies.

Personnel

1. **Project Manager:** Responsible for project planning, coordination, and overall management, including resource allocation and schedule supervision.
2. **Electrical Engineer:** Expert in energy systems and energy efficiency, responsible for designing and overseeing the implementation of energy management solutions.
3. **Software Developer:** Programmer with experience in developing applications and software for system management and control.
4. **Automation Engineer:** Specialist in control system automation, capable of designing and implementing intelligent automation solutions.
5. **Network Engineer:** Responsible for designing and maintaining the communication infrastructure to connect all devices and systems.
6. **Data Analyst:** Professional in charge of collecting, analyzing, and presenting data for decision-making and report generation.
7. **Renewable Energy Expert:** Specialist in renewable energy sources, responsible for the integration of solar, wind, or other sustainable sources.
8. **Designer (UI/UX):** Designs the system's user interface to be intuitive and user-friendly.
9. **Expert in Energy Legislation and Regulations:** Ensures that the system complies with local and national energy regulations and standards.

10. **Database Administrator:** to ensure that databases run efficiently, securely, and are always available.

Money

1. Project Manager: $20,500 mxn per month.
2. Electrical Engineer: $10,000 mxn per month.
3. Software Developer: $10,000 mxn per month.
4. Automation Engineer: $10,000 mxn per month.
5. Network Engineer: $10,000 mxn per month.
6. Data Analyst: $9,000 mxn per month.
7. Renewable Energy Expert: $10,500 per month.
8. UI/UX Designer: $9,000 mxn per month.
9. Expert in Energy Legislation and Regulations: $12,500 mxn per month.
10. Database Administrator: $10,000 mxn per month.

Overall Monthly Salary = $111,500
Project Cost (10 months) = $1,115,000

Time

10 months.

CR1

New Requirement:

- **Additional remote server:** The client requests an additional master remote server for getting reports of usage for several buildings in different cities, it includes a module in your original project that connects to the remote server.

Modules

1. **Centralized Building Management:** This module will act as a central platform that allows adding and managing multiple buildings within the system. It enables the creation of profiles for each building and facilitates centralized administration.
2. **Remote Connection:** Adds secure remote connection functionalities, such as VPN or cloud access, to ensure authorized users can access all building systems securely and remotely.
3. **Update Multi-site Notification Module:** Expand the alarm and notification management module to include alerts that cover multiple buildings. This allows receiving notifications about critical events in any location.
4. **Update Multi-site Reporting Module:** Expand reporting generation capabilities to create consolidated reports covering multiple buildings, making it easier to compare and analyze data across multiple locations.

Personnel

1. **Security Expert:** Responsible for ensuring the security of project data and systems against cyber threats.
2. **Quality Control Specialist:** Responsible for ensuring the system meets quality and performance standards.
3. **Technical Support Staff:** Provides support and technical assistance to users and resolves operational issues.
4. **Training Personnel:** Provides training to end-users and the team on system usage.

Money

1. **Security Expert:** $11,500 mxn per month.
2. **Quality Control Specialist:** $10,000 mxn per month.
3. **Technical Support Staff:** $7,500 mxn per month.
4. **Training Personnel:** $8,500 mxn per month.

Overall Monthly Salary = $37,500 mxn.
Project Cost (12 months) = $447,996 mxn.
Total = $1,788,000 mxn.

Time
2 months - this would be **%20**

Effort
The amount to increase is $673,000 mxn - this would be **%60**

CR2

New Requirement:

- **Customization:** the system must include screen customization according to the needs of the company's image, including screen color, logo configuration and addition/deletion.

Modules

- **User profile:** a new module will be created that will serve to configure the profile of each company in which the system is implemented, where the user will be able to manage the customization of the screen according to their needs.

Personnel
To add these new requirement it will not be necessary to hire new personnel.

Time
2 months - this would be **%20**

Money
The amount of the monthly salary remains the same, only two more months of production will be increased, remaining as follows:

Overall Monthly Salary = $111,500.
Project Cost (12 months) = $1,338,000.

Effort
The amount to increase is $223,000 - this would be **%20.**

CR3

New Requirement:

- **State of the components:** due to the new characteristics of sensors and actuators, the client requests a more interoperable architecture that records the internal state of each component. Statuses range from operable, off, broken, and running.

Modules

- **Device and sensor management:** a new module must be added which will record the internal state of each component.

Personnel

- **Hardware Engineer:** Helps design the architecture needed to collect internal data from devices and sensors.
- **Firmware Developer:** Works on developing the firmware necessary to collect and record the internal state of components.

Time

4 months - this would be **%40.**

Money

1. **Hardware Engineer**: $19,000 mxn per month.
2. **Firmware Developer**: $16,000 mxn per month.

Overall Monthly Salary = $35,000 mxn.
Project Cost (14 months) = $2,051,000 mxn.

Effort

The amount to increase is $936,000 - this would be **%83.**

CR4

New Requirement:

- **Automatic reports:** Due to a new ecological standard, every system must report the energy efficiency of the monthly operation of the system.

Modules

- **Multisite reporting module update:** add new functionality that allows the generation of automatic reports. This new feature allows users to configure the desired date range for generating their reports.

Personnel
To add these new requirement it will not be necessary to hire new personnel.

Time
1 month. - This would be **%10.**

Money
The amount of the monthly salary remains the same, only one more month of production will be increased, remaining as follows:

Overall Monthly Salary = $111,500 mxn.
Project Cost (11 months) = $1,226,500 mxn.

Effort
The amount to increase is $111,500 - this would be **%10**

Criteria

Criteria	
Budget	25%
Time	30%
RH	5%
Work effort	20%

Requirement	Budget	Time	RH	Effort	Risk	Law Mandatory	First Approval	Ranking	Final decision
CR1	60%	17%	4	38.5%	High	No	Rejected	2	Approved
CR2	20%	17%	0	18.5%	Low	No	Approved	3	Approved
CR3	83%	33%	2	58.0%	Medium	No	Rejected	4	Rejected
CR4	10%	8%	0	9.0%	High	Yes	Approved	1	Approved

The approval of these requirements is based on fundamental considerations to enhance the system's functionality and meet the client's expectations and needs.

1. Firstly, the inclusion of an additional remote server is justified by the client's need to obtain reports on the usage of various buildings in different cities. This not only optimizes centralized monitoring but also strengthens the system's ability to scale and expand, which is crucial for efficient management on a large scale.
2. The customization of the system directly addresses the adaptation to the client's corporate image. Allowing visual adjustments, such as screen colors and logo configurations, not only improves the user experience but also ensures a consistent and professional integration of the system into the business environment.
3. The approval of automatic reporting is grounded in the need to comply with new ecological regulations. This not only ensures compliance with environmental regulations but also demonstrates the project's commitment to sustainable practices. The automatic report generation contributes to environmental responsibility and enables continuous assessment of the system's energy efficiency, ensuring alignment with current standards.
4. Lastly, the request for implementing "Component Status" was declined due to cost and time considerations. While we acknowledge its importance in recording the internal state of each component, the added complexity and significant increase in resources required for implementation do not fully justify the additional benefits compared to current solutions. The decision was made to ensure the economic and temporal viability of the project, prioritizing functionalities that strike an optimal balance between added value and efficiency in resource utilization.

Status Accounting

Status accounting in software configuration management involves the detailed tracking and recording of configuration items and their changes throughout the software's life cycle. This section addresses the importance of maintaining accurate and up-to-date records to facilitate informed decision-making, understand software evolution, and ensure the integrity and availability of relevant information.

History of changes

This section titled "Change History" provides a detailed timeline of the project's evolution and adjustments from its inception to the final version. It offers a retrospective view of the decisions, modifications, and enhancements that have shaped the development of the intelligent system for energy efficiency in public buildings.

Date	Activities
August - September 2023	• It began by indicating that a project should be chosen for the class, which should not be developed, only documentation, and it was suggested that it not be too large. • Select the project titled “Development of an Intelligent Energy Efficiency System in Public Buildings”. • An initial presentation was made to explain what the project is about. • He introduced himself to the group and the teacher, who made some corrections or suggestions to my project.
September 2023	• It was agreed to prepare the first analysis document which was called Baseline 1.0. • It was presented to the group and teacher, who suggested some changes and added a new requirement for analysis. • Some use case diagrams were created to complement the analysis part, in the Baseline 1.0 document. • The first context was made which mentions everything that the project implies such as time, money, human resources and effort, this document was titled Contex.
	• The Context document was presented, from which several comments and corrections were made. • It began with the drafting of the company's Policy document, which details, among several topics, how

October 2023	the project committee is formed, scales of importance for decision-making within the company. • This document was presented and the necessary corrections were made. • 3 new requirements were integrated, asking for the same description of the Contex document, which was updated by adding these 3 requirements separately.
November 2023	• Several changes were made to the Policy document, to which the roles, activities and responsibilities of the committee members were added. • An evaluation of results was carried out, with the Context document, from which the Criteria document emerged, which defines the criteria to evaluate the decision-making to accept or reject the new requirements. • The draft of this "Master document" was presented, of which several changes were requested.
December 2023	The final version of this document was concluded.

References

[1] S. C. Hernández, *Smart Energy Management System for Public Buildings,* Ameca, Jalisco: N/A, 2023.

[2] S. C. Hernández, «GitHub,» Software Configuration Management, 01 12 2023. [En línea]. Available: https://github.com/vacha1992/Software_Configuration_Management.git. [Último acceso: 01 12 2023].

[3] S. C. Hernández, *Baseline 1.0,* Ameca: N/A, 2023.

[4] S. C. Hernández, *Policies,* Ameca: N/A, 2023.

[5] S. C. Hernández, *Context,* Ameca: N/A, 2023.