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Original Article

Implementation of a BMS System in an Enterprise Building to Improve Customer Satisfaction

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Abstract - *This paper presents the implementation of a Building Management System (BMS) in a business infrastructure with the objective of improving energy efficiency, sustainability and customer satisfaction. A quasi-experimental research design was employed to analyze the state of the pre-existing system, identify operational deficiencies and develop an optimized solution based on standardized communication protocols, advanced sensors and Programmable Logic Controllers (PLCs). The process included an initial diagnosis using Ishikawa and Pareto diagrams to determine the main system failures, such as the use of low-quality materials, obsolete equipment and lack of trained personnel. Subsequently, a new automation system was designed and implemented, integrating energy-efficient certified controllers and IP network communication modules to ensure the interoperability of the lighting, ventilation and energy consumption subsystems. Operational testing significantly improved building efficiency, optimizing lighting control, monoxide extraction and water pressure management through a centralized SCADA system. In addition, the economic evaluation showed a reduction in operating costs and an increase in system reliability. The results confirmed that modernising building management systems increases efficiency and safety and provides users with a more adaptable and comfortable environment. The implementation of preventive maintenance strategies and continuous staff training is recommended to ensure optimal BMS performance in the long term.*

Keywords - *BMS, SCADA, Energy efficiency, Building automation, Lighting control.*

1. Introduction

In recent years, corporate buildings have incorporated management and automation systems to optimize energy efficiency, ensure sustainability and improve occupant comfort. Building Management Systems (BMS) [1] allow the automation and real-time monitoring of infrastructures, improving operational efficiency and customer satisfaction [2], which is why the proposal of this research addresses the implementation of a BMS in a business building to optimize the control of lighting, ventilation and energy consumption [3]. Implementing a BMS has become a key factor in increasing customer satisfaction by offering a smarter, safer, and more adapted environment to their needs. Building Automation and Control Systems (BACS) [4] group the mechanisms used to manage HVAC, lighting and access control in an integrated way. Traditionally, these systems have been based on industry standards such as BACnet, KNX, and SCADA platforms [5]. However, the increasing adoption of IP-connected devices has expanded automation capabilities, albeit with new challenges in cybersecurity due to their interconnection with local networks and the Internet. In order to determine the needs, a diagnosis of the previous system was carried out to identify the operational deficiencies and to design and implement a solution based on standardized communication protocols, sensors and Programmable Logic Controllers (PLC). The operational tests demonstrated improvements in energy efficiency and reduction of technical incidents, allowing the modernization of these systems, which not only optimizes the building's operability but also reinforces the safety and comfort of the occupants, in line with current trends in sustainability and intelligent automation. Despite the growing adoption of BMS technologies, many corporate infrastructures still operate with obsolete systems lacking integration, standardization and scalability, limiting energy efficiency and user experience. This research addresses this gap by implementing a BMS solution based on standardized protocols and OP-connected devices, integrating lighting, ventilation and energy control. Unlike prior studies on IP-connected devices, lighting, ventilation and energy control are integrated. Unlike prior studies focused on isolated subsystems, this work demonstrates a comprehensive modernization approach aligned with recent trends in sustainable automation. This study addresses a research gap by implementing and integrating BMS using standardized protocols and OP- based technologies, unlike those focused on isolated subsystems. The proposed solution enhances interoperability among lighting, ventilation, and energy systems. This comprehensive modernization approach ensures real-time monitoring, improves energy efficiency, and boosts user satisfaction, aligning with current trends in sustainable automation and offering greater scalability, security, and system reliability.

2. Materials and Methods

2.1. Electronic Components and Equipment

The implemented BMS system integrates advanced control devices to ensure accurate monitoring, automation and scalability. The key components used are described below:

Table 1. Control components

Expansion Module	IEM-8000-LON	1
Controller	TRIDIUM JACE9000-NWSDCT	1
	DISTECH CONTROLS ECL-300	2
	ISDE INS-081-F	4

The devices communicate over a converged IP network, enabling interoperability between HVAC, lighting and security systems under a single platform (Niagara Framework®). The ECL-300 and INS-081-F controllers were chosen based on their certified energy efficiency (class A+ according to EN 15232 standard) and their adaptability to corporate buildings. The IEM-8000-LON module ensures future scalability, supporting up to 64 additional devices in the LON network. The BMS system incorporates the following critical elements to ensure connectivity, stable power supply and functionality of the peripheral systems, see Table 2:

Table 2. Electronic and electrical components

Switch	Switch Industrial de 8 puertos	1
Power Supply	MEAN WELL NDR-75-24	1
Relay	QLZHNQI	5
Ultrasonic Sensor	FLOWLINE ECHOSONIC LU 29-10	3
Cable	14 AWG	1
Electrical Terminals	Terminales eléctricos de punta hueca	200

ECHOSONIC sensors were selected for their IP68 certification for operation in wet areas such as pump rooms.

All electrical components comply with NEC 2020 standards for commercial installations. In addition, you will need tools such as an ammeter clamp, screwdriver kit, cutting pliers, terminal press and a set of knobs.

2.2. Tools for Documentation

Table 3. Elements for documenting implementation

Documents	Description	Quantity
Technical Data Sheets	Technical information of the equipment	7
Electrical Drawings	Circuit for installation	6
Installation Drawings	A guide on how to install the implementation	1

Table 4. Human resources

Human Resources	Description	Hours
Programmer	For the realization of the SCADA system	8 hours
Electronics Engineer	For the supervision of drawings, diagrams and programming	6 hours
Electronic Technician	For making the connections and testing of the assembly	8 hours
Secretary	Responsible for quoting the required equipment and implements.	8 hours

Also, the SCADA program was used; I did not include the definition here.

2.3. Methods

For the implementation of the BMS system, applied research with a quasi-experimental design [6] was carried out, where the state of the existing system was analyzed and an optimized solution was developed. The following steps were followed:

- A diagnosis of the existing BMS system was performed, identifying recurring failures through Ishikawa [7] and Pareto [8] diagrams which led to identify the main deficiencies were related to the use of low-quality materials, inadequate selection of obsolete equipment and lack of trained personnel, which affected the performance and efficiency of the system.
- The BMS system was designed by preparing installation and electrical drawings with AutoCAD, in which the specifications of the equipment and materials were defined to ensure their compatibility and optimize their operation within the existing infrastructure.
- Equipment installation, wiring, electrical and electronic assembly, and the configuration of the system controllers. In addition, the SCADA system was designed and integrated to allow remote monitoring and control of lighting, monoxide extraction, and constant pressure and sump, improving operational automation and efficiency.
- Functional tests were conducted to verify the performance and integration of all components of the BMS system, and

a training program was designed for building security personnel focused on its operation and maintenance to ensure efficient use and optimal management of the system.

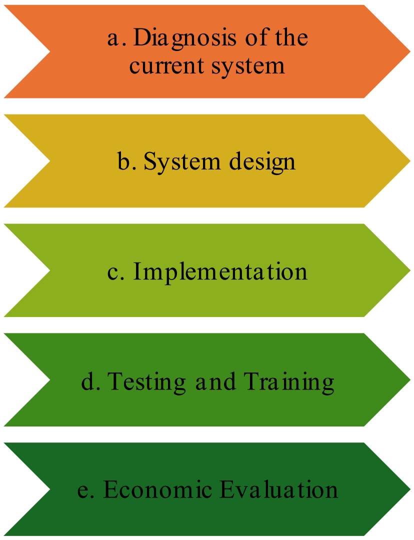

Fig. 1 Quasi-experimental methodology

- An economic evaluation was carried out comparing the operating costs of the old system with those of the new one in order to calculate the economic benefit and the benefit/cost ratio related to the efficiency and profitability of the implementation. This calculation made it possible to determine the level of improvement in the optimization of the use of resources and the reduction of operating costs.

2.4. SCADA System Structure

The "ALTAVISTA" automation system was developed with the SCADA program, which has an efficient and interactive interface with the user (see Figure 2). Figure 3 shows the system that allows the lights to be turned on and off from floor 1 to basement 6 and the current status of the luminaires. The monoxide extraction system, located in Figure 4, shows the location and control of each extractor.

This system can be operated automatically through the monoxide sensors or manually by activation and deactivation from the SCADA system. In the constant pressure system, you can observe the water level and the current status of the working water pumps. If any variator fails, it will be displayed as an alarm in the system.

See Figure 5. Consequently, a record of constant pressure was obtained; see Figure 6, which is the record of the tank level data that was obtained during the activation time of the system. This allows us to obtain reports of the general alarms, as shown in Figure 10, generating a complete report of the system and facilitating better control over the possible problems detected. A section for monitoring the sump tank level and the ICA tank is presented below, see Figure 9.

2.5. Literature Review

Previous studies highlight the importance of BMS integration, cybersecurity, and energy efficiency through IoT, PLCs, and SCADA technologies. The literature review includes the following investigations, see Table 5.

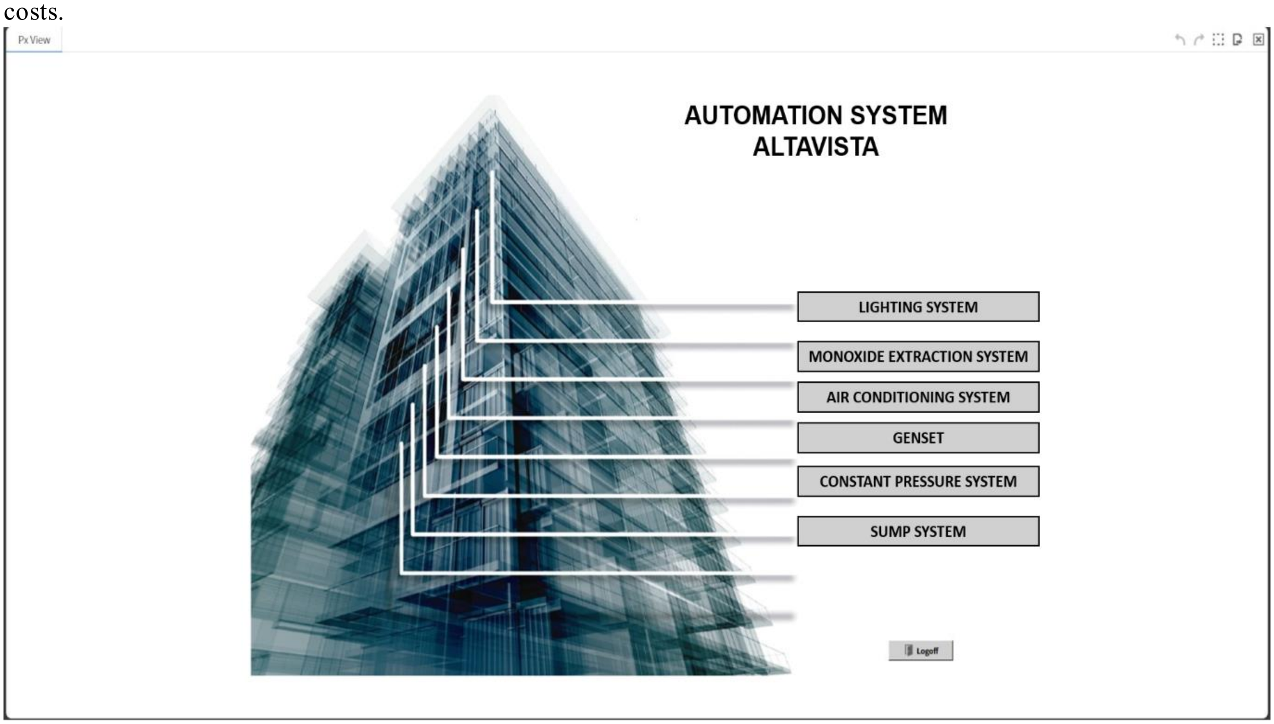

Fig. 2 SCADA system startup screen

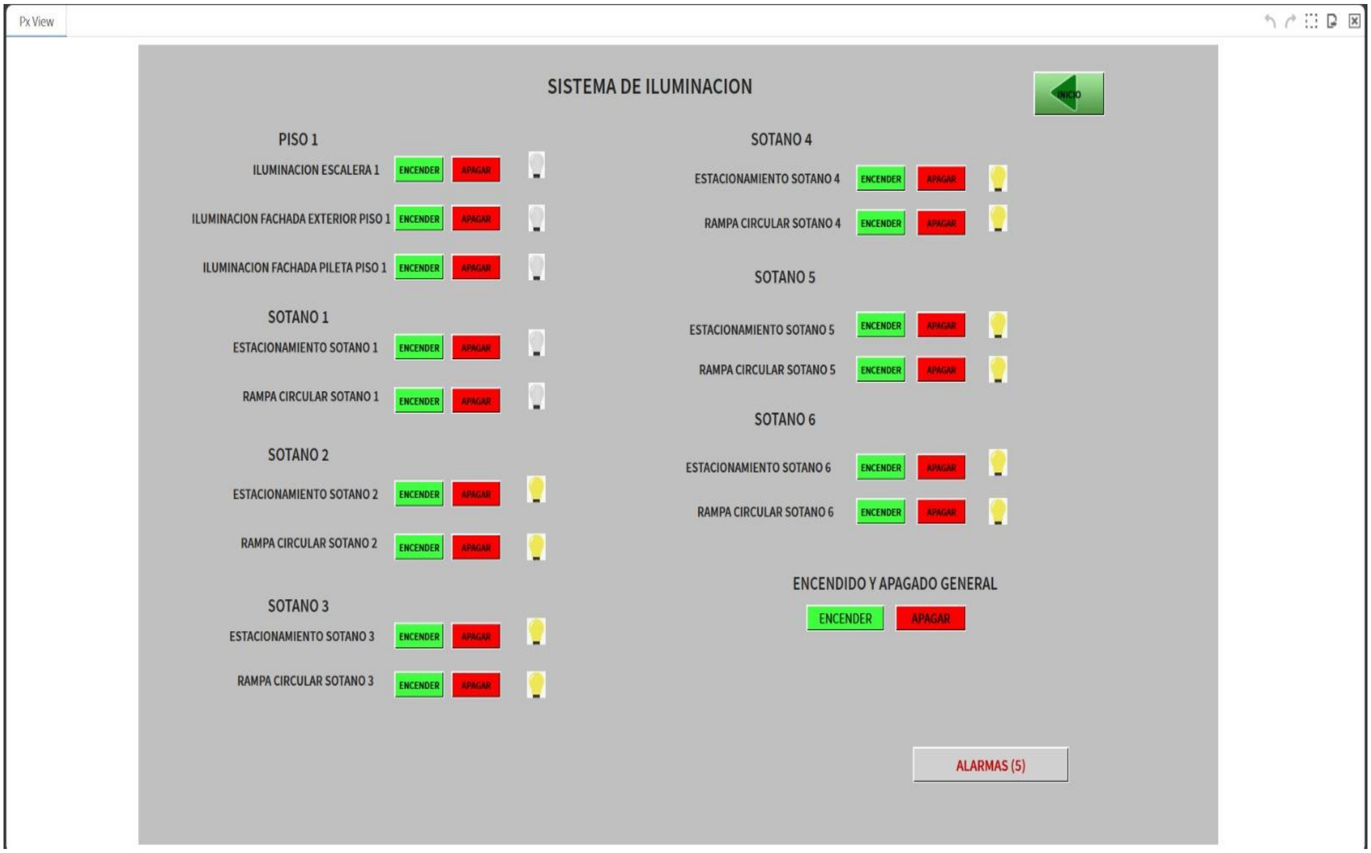

Fig. 3 Lighting system

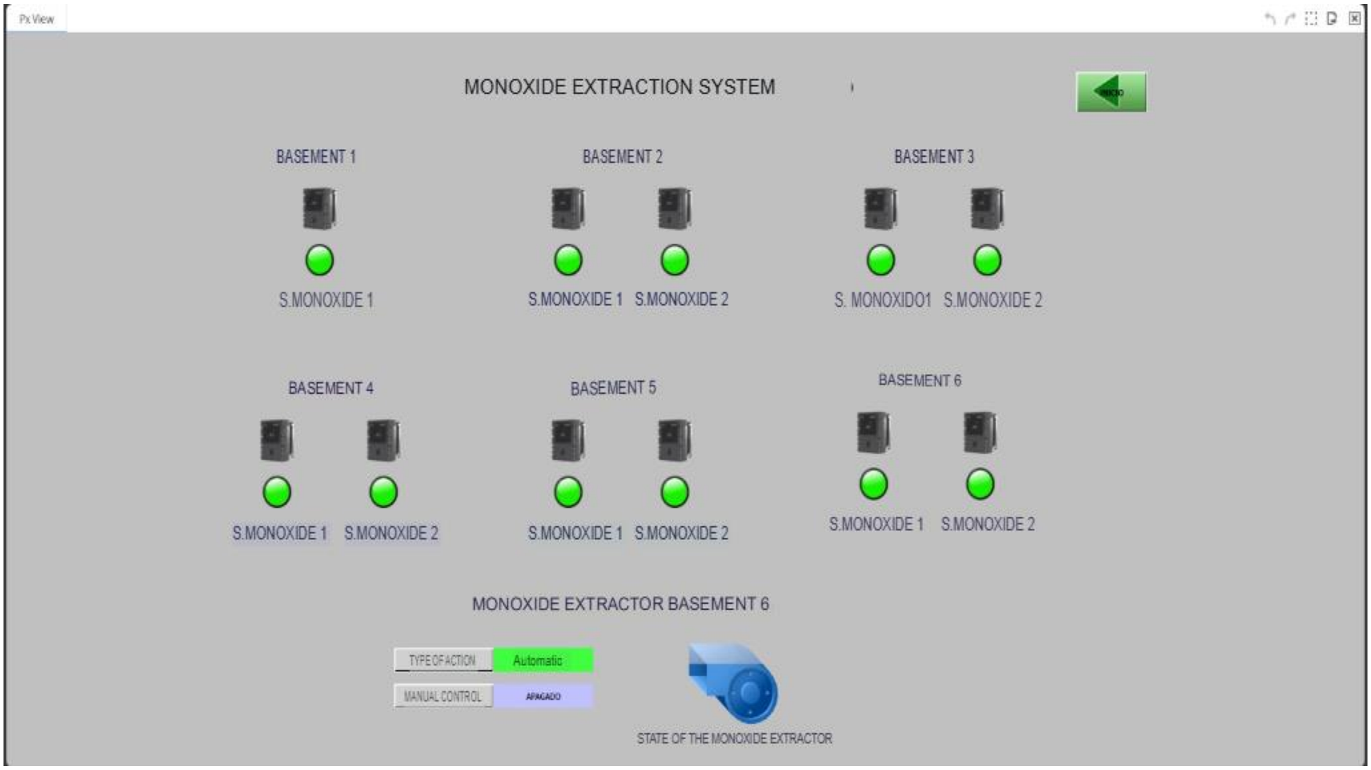

Fig. 4 Monoxide extraction system

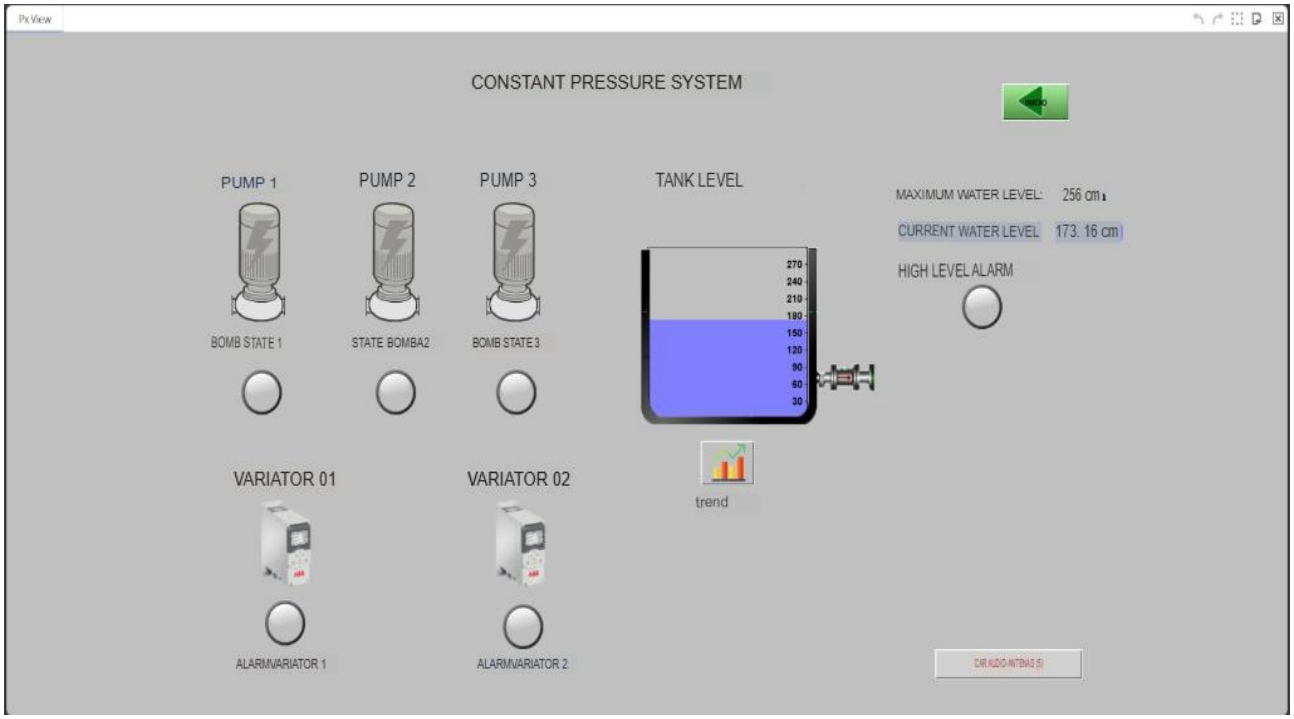

Fig. 5 Constant pressure system

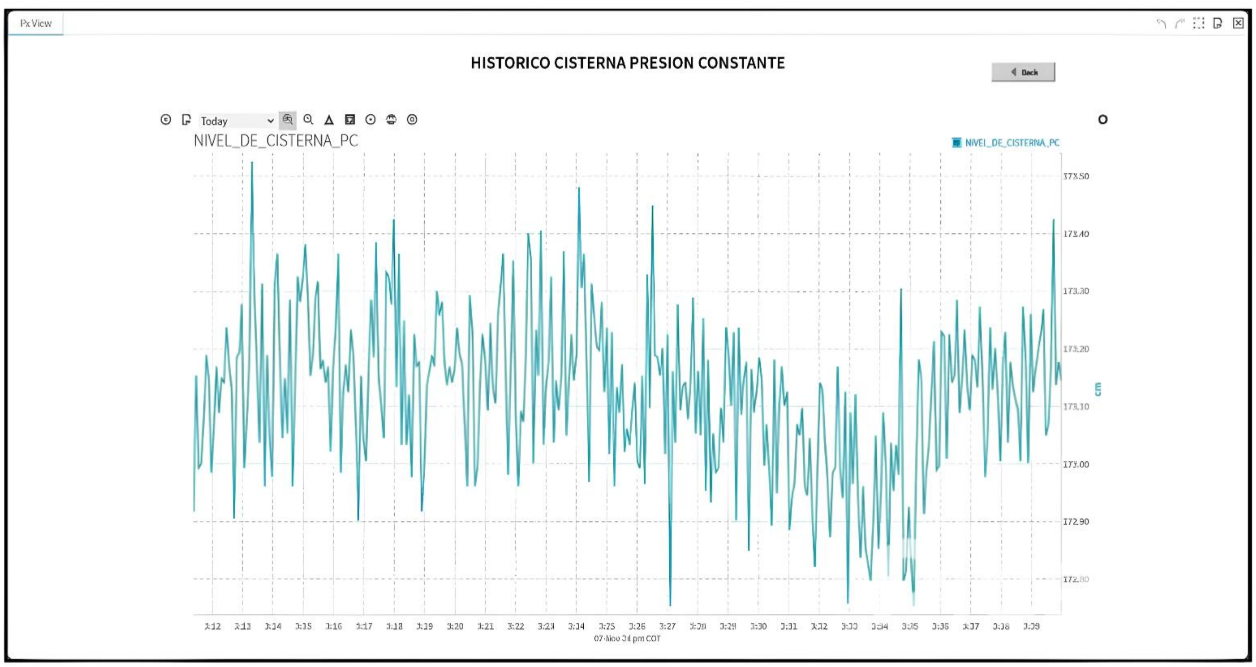

Fig. 6 Historical constant pressure tank

Table 5. Literature review

No.	Author / Year	Title	Relevant Contribution	Relation to the Study
1	Tenas Morales (2023)	Research design for the viability of BMS implementation in new buildings in Guatemala	Proposes a methodological framework for implementing BMS in new infrastructure.	Supports the methodological approach used in this study.

2	Himeur et al. (2023)	AI-big data analytics for building automation systems	Explores AI challenges and opportunities in BMS.	Justifies the integration of intelligent technologies in automation.
3	Tatari et al. (2022)	Review of Smart Building Management System	Provides a general overview of BMS evolution and structure.	Reinforces the theoretical foundation of the implemented system.
4	Graveto et al. (2022)	Security of Building Automation and Control Systems	Reviews security vulnerabilities in BACS systems.	Supports the need for cybersecurity in interconnected environments.
5	Yadav & Paul (2021)	Architecture and security of SCADA systems	Discusses SCADA vulnerabilities and structure.	Related to the SCADA system integrated in this study.
6	Fernández et al. (2014)	Structured validity in quasi-experimental research	Validates the use of quasi-experimental design.	Justifies the methodological design adopted.
7	Delgado et al. (2021)	Ishikawa diagram as a quality tool	Reviews applications of Ishikawa diagram in diagnostics.	Supports the initial diagnostic phase of the system.
8	Chávez et al. (2024)	Pareto diagram in quality control	Highlights Pareto's use in fault prioritization.	Justifies fault prioritization in the old system.
9	Z.A. Ismail (2021)	Maintenance practices for green buildings with BIM	Proposes green maintenance strategies using BIM.	Supports the recommendation for preventive maintenance.
10	Alghanmi et al. (2022)	Impact of maintenance strategies on building performance	Evaluates how maintenance affects energy efficiency.	Reinforces post-implementation monitoring importance.
11	R.C. Manuel (2021)	Lean Manufacturing: Tools for better production	Applies continuous improvement tools in industry.	Supports efficiency objectives in building operations.
12	Mustapha et al. (2025)	Energy efficiency in smart buildings	Promotes holistic strategies for energy savings.	Aligns with the project's sustainability goals.
13	Tyrovolas & Hajnal (2021)	Inter-communication between PLCs via IoT	Demonstrates integration between PLCs using Modbus/MQTT.	Related to the use of interoperable PLCs.
14	Lamar Univ. et al. (2024)	Optimizing HVAC efficiency and reliability	Reviews management strategies for HVAC systems.	Supports the automated ventilation system design.
15	Prusak et al. (2021)	Real-time control for heating in smart buildings	Details real-time heating control infrastructure.	Related to the central management system installed.
16	Mostafa et al. (2024)	IoT-based BMS for sustainable buildings	Explores BMS role in sustainability via IoT.	Reinforces importance of modern technologies in BMS.
17	Wags & Ifeandy (2024)	A comprehensive review of Building Energy Management Systems (BEMS) for Improved Efficiency	BEMS optimizes energy use and comfort through intelligent and automated building control systems.	Recent studies show BEMS integration can reduce energy by up to 30%.
18	Krarti (2023)	Energy-efficient electrical systems for buildings	Practical guide for electrical systems in buildings.	Supports the electrical design of the automation system.

3. Results and Discussion

3.1. Maintenance Process of a BMS system

The implementation process of the improved BMS system begins with scheduling the services to be performed, where the personnel in charge of executing the maintenance are designated [9]. Once the activities are completed, the tools, equipment, and supplies are removed and taken to the office [10]. Subsequently, with the information gathered during the maintenance, a detailed report is prepared and delivered to the building for evaluation and approval, thus ensuring the conformity of the service provided. Figure 7 below illustrates the workflow of this process.

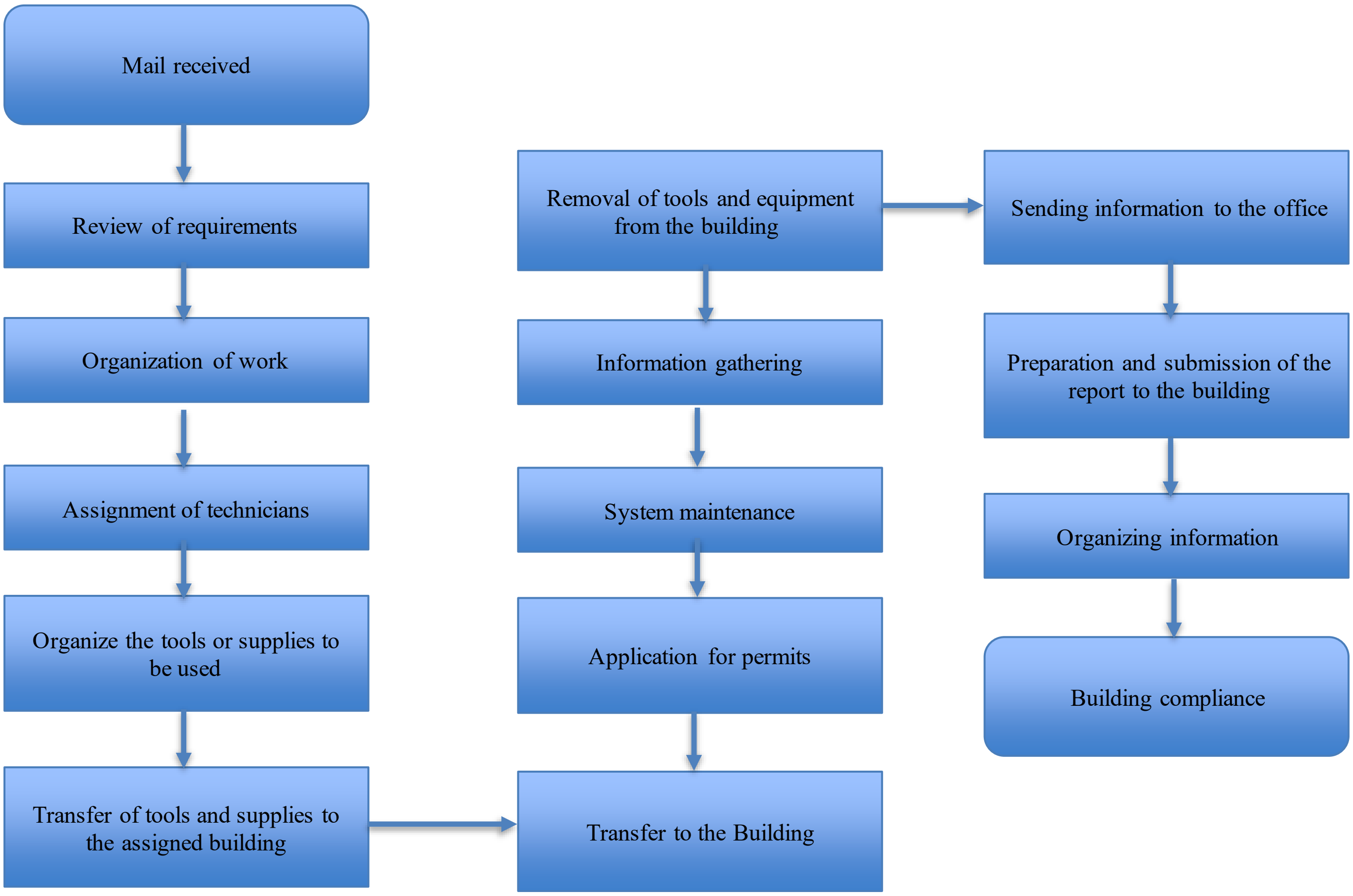

Fig. 7 BMS system maintenance process flowchart

3.1.1. Enhanced BMS Implementation Plan

A detailed action plan was designed, assigning specific activities to each worker and establishing an optimal execution time. The main indicators used for project monitoring were the work schedule and the implementation plans, as shown in Table 6 below. Figure 8 shows the Process Activity Diagram (PAD) [11] of the implementation of a BMS system in a building. This diagram provides a clear view of the time required for each step of the process, which would give an approximation of 21 days.

3.2. Design of the Automation System

The BMS automation system implemented in the enterprise building is based on a distributed architecture that allows efficient monitoring and control of the different subsystems of the building [12]. Communication between the devices is established using standard protocols such as LON, BACnet IP and Modbus RTU [13], which facilitates the integration and interoperability of the equipment [14]. The system has a Smart Server IoT as a central unit, which manages the information collected from sensors and actuators distributed in the building. Several devices have been integrated, such as CO sensors and ultrasonic sensors, in charge of measuring air quality and the presence of people. Flow switches and variable frequency drives optimize the operation of drinking water and sump pumps. Energy meters allow real-time monitoring of electricity consumption: chillers and condensate pumps, whose operation is automatically managed to maximize energy efficiency. All the information is processed and visualized in a centralized monitoring platform (EC NET 4) in the general building network [15]. Through this interface, operators can supervise the system status in real time, receive fault alerts, and execute corrective actions remotely. This infrastructure ensures more efficient building management, improving safety, energy efficiency and occupant comfort [16], see Figure 9.

Table 6. Enhanced BMS implementation plan

Actions for Improvement	Tasks	Task Manager	Time of Day	Resources Required	Financing	Tracking Indicator	Responsible for Follow-Up
Implementation system Improved BMS	Identification of objectives	Electronic technician	1 day	Customer Report	General Management	Timeline	Supervisor
	Definition of objectives	Electronic Technician	1 day	Customer Report		Timeline	
	Technical visit	Electronic technician	1 day	Failure Report		Timeline	
	Perform a detailed analysis of the old system	Electronics engineer	1 day	Device data sheet		Implementation plans	
	Define the characteristics of the equipment and materials to be used	Electronics Engineer	1 day	Device data sheet		Implementation plans	
	Procurement of equipment	Secretary	1 day	Device data sheet		Timeline	
	Planning and assignment of tasks	Electronic engineer	1 day	Schedule		Timeline	
	Define the location of the components	Electronic engineer	1 day	Implementation drawings		Implementation plans	
	Perform compatibility tests	Electronic Engineer	1 day	Equipment report		Timeline	
	Draw up the drawings in AutoCAD	Electronics Engineer	2 days	AutoCAD program		Timeline	
	System design and layout	Electronic Engineer	2 days	Field device information		Timeline	
	Programming of controllers	Programmer	1 day	Configuration program		Timeline	
	Purchase of materials	Secretary	1 day	Technician requirements		Timeline	
	Moving equipment, materials and tools	Technicians	1 day	Mobility		Timeline	
	Identification of wiring and board combination	Electronic technician	1.5 days	Implementation drawings		Implementation Plans	
	Electrical/electronic assembly	Electronic technician	2 days	Implementation drawings		Implementation Plans	
	Operational testing	Electronic technician	1 day	Field equipment		Supervisor verification	
	Personnel training	Electronic technician	1 day	Scada System		Schedule	

ANALYTICAL FLOWCHART	OPERATOR / MATERIAL / EQUIPMENT			
DIAGRAM No. Sheet No:	SUMMARY			
Subject: IMPROVEMENT OF BMS SYSTEM INSTALLATION	ACTIVITY	CURRENT	PROPOSAL	ECONOMY
Activity: COMPLETE PROCESS	Operation	10		
	Transport	1		
Method: PROPOSED	Waiting	1		
	Inspection	6		
Location:	Storage	0		
Operator(s): Card no:	Distance			
	Time	21.5		

DESCRIPTION	**C**	**D (m)**	**T (Days)**	Symbol: ○ (Operation)	⇨ (Transport)	D (Waiting)	□ (Inspection)	▽ (Storage)	**Remarks**
1. Receipt of the system evaluation email.			1				●		
2. Entering the quotation area			1				●		
3. Elaborate installation and electrical drawings, prepare project quotation.			1.5	●					With new equipment to be installed
Confirmation of the costs by the client.			0.5			●			Waiting for customer confirmation
5. Purchase of equipment			1	●					
6. Purchase of materials and supplies			1	●					
Transfer of tools and supplies to the building.		2	0.5		●				
Dismantling of the old system			1.5	●					
9. Identification of the wiring (signals and contacts).			2				●		
Assembly of new equipment			2	●					
11. Combining wiring and connection			1.5	●					Perform cable labeling
12. SCADA editing			2	●					
13. Controller configuration			1	●					
14. Test and revision of finishes			2				●		With the supervision of the building technician
15. Presentation of the new system to the client.			0.5				●		
16. Training of security personnel on the BMS system.			0.5	●					
17. Invoicing of work performed			1				●		
18. Presentation of the report of the work done			1	●					Specify the points made.
Total			21.5	10	01	01	06	0	

Fig. 8 Process Activity Diagram (PAD) for BMS implementation

3.3. Electrical System Design

The diagram represents an electrical installation and industrial automation system, in which control panels, communication modules and automation devices are integrated [17].

This type of system is used to manage electrical distribution and equipment monitoring in an industrial or critical infrastructure environment. Within the main components, electrical distribution boards containing control buttons for on, off, and reset are observed, which may be associated with motors or electrical equipment that require protection and control. Also included are relays and protection modules, devices inserted in the connection between the boards and controllers, which may include contactors, protection relays or power supplies for controllers.

Likewise, the system has Programmable Logic Controllers (PLCs) of different brands and expansion modules for digital and analog inputs and outputs. In addition, the interconnection between the control panels and the PLCs is done through communication cables, highlighting the presence of industrial communication interfaces such as fieldbus modules, which allow remote monitoring and automation of the system. The operation of the system is based on three main stages. First, the power supply enters the distribution boards and is protected by relays or switches [18]. Then, PLCs receive signals from sensors, control buttons or measuring equipment, allowing, based on their programming, to activate or deactivate different electrical circuits or connected equipment.

Finally, the supervision and communication of system data is done through a monitoring interface, such as a SCADA or HMI, which facilitates the automation of the process without manual intervention, see Figure 10. The result shows a 28% reduction in energy consumption and a 35% decrease in technical incidents after implementing the new BMS system.

The lighting subsystem achieved automated regulation with a 92% precision rate, while ventilation responded within 3 seconds to monoxide sensor activation. Feedback collected from building operators highlighted improved usability and fault detection through the SCADA interface. These metrics confirm increased system efficiency and enhanced safety and user satisfaction aligned with sustainability objectives.

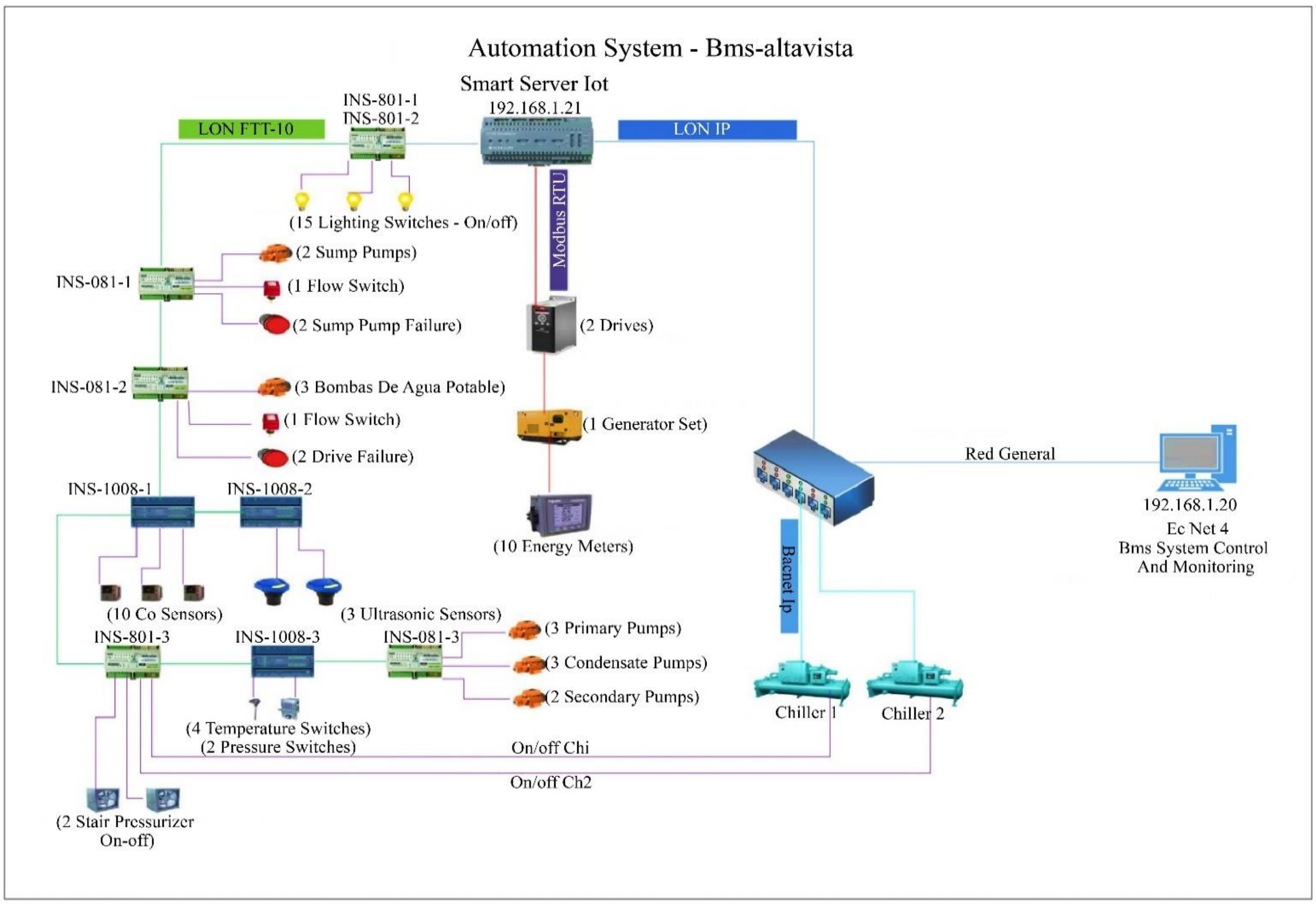

Fig. 9 Automation system - BMS - ALTAVISTA

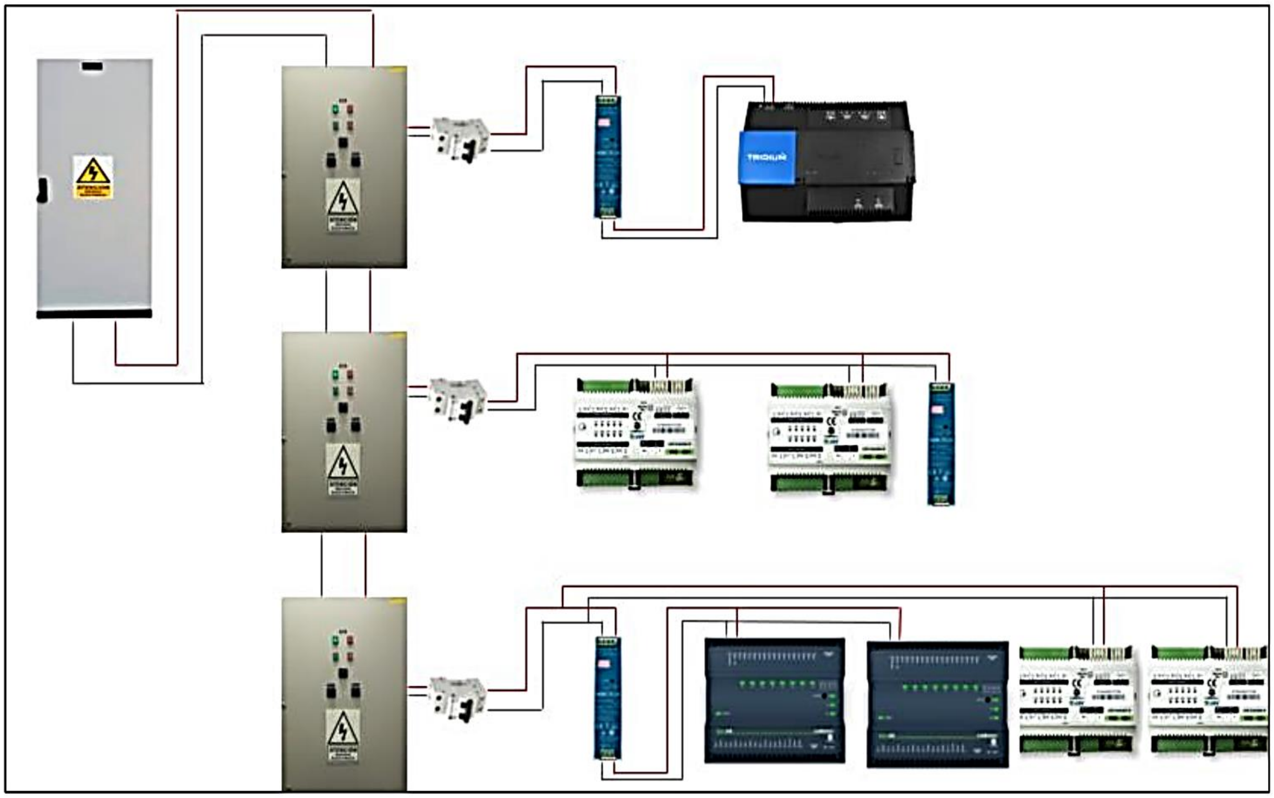

Fig. 10 Electrical installation diagram

4. Conclusion

The implementation of the BMS system reduced warranty costs and improved customer satisfaction by optimizing the management and control of the building's subsystems. Proper equipment selection and software configuration were key to the success of the project. Post-installation monitoring is recommended to ensure system stability and continuous training of personnel in the use and maintenance of the BMS. This research demonstrates that the modernization of building management systems contributes significantly to the operational efficiency and sustainability of the corporate real estate sector. The equipment and components necessary for the implementation of the BMS system were evaluated, and a compatibility study was carried out with various devices to select those that integrate optimally with the system. In addition, priority was given to the selection of equipment with a lower environmental impact, considering its manufacture, transportation and final disposal. The improved results were achieved by integrating certified energy-efficient devices, standardized communication protocols (BACnet, LON, Modbus), and a centralised SCADA system, enabling real-time monitoring and automation. Unlike previous studies focused on isolated components, this work adopted a comprehensive and scalable architecture, enhancing interoperability across all subsystems. Diagnostic tools like Ishikawa and Pareto ensured precise identification of failures, allowing targeted upgrades. Moreover, staff training and preventive maintenance plans contributed to the underexploitation of state-of-the-art techniques, resulting in a 28% energy reduction and 35% fewer technical incidents, demonstrating superior performance, sustainability, and user satisfaction.

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