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Key words:
building management system (BMS); student housing complex; energy simulation; HVAC system

INTEGRACIJA SISTEMA ZA UPRAVLJANJE ZGRADOM U STUDENTSKOM DOMU

INTEGRATING A BUILDING MANAGEMENT SYSTEM WITHIN A STUDENT HOUSING COMPLEX

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Integracija Sistema za upravljanje zgradom (BMS) u infrastrukturu studentskog smeštaja predstavlja ključni korak ka postizanju veće energetske efikasnosti, optimizacije rada i komfora stanara. Ovaj rad prikazuje implementaciju i analizu BMS-a u okviru kompleksa studentskog smeštaja u Temišvaru, koji je u vlasništvu i pod upravom Zapadnog univerziteta u Temišvaru. Cilj istraživanja je da se procene unapređenja energetske performanse i koristi u upravljanju, proistekle iz uvođenja automatizovanog sistema kontrole glavnih instalacija zgrade. Studija započinje izlaganjem osnovnih principa i komponenti Sistema za upravljanje zgradom, naglašavajući njegovu ulogu u praćenju, kontroli i optimizaciji tehničkih sistema zgrade, kao što su HVAC, rasveta i elektrodistribucija. Radi kvantifikacije koristi od implementacije BMS-a, sprovedena je energetska simulacija korišćenjem softvera Vabi Elements. Modelirana su dva operativna scenarija: postojeća konfiguracija zgrade bez sistema upravljanja i optimizovana verzija opremljena potpuno funkcionalnim BMS-om. Rezultati simulacije ukazuju na značajno smanjenje ukupne potrošnje energije i poboljšan termalni komfor zahvaljujući dinamičkoj kontroli HVAC sistema i upravljanju energijom u realnom vremenu.

The integration of a Building Management System (BMS) into student housing infrastructure represents a key step toward achieving higher energy efficiency, operational optimization, and occupant comfort. This paper presents the implementation and analysis of a BMS within a student housing complex located in Timisoara, owned and managed by the West University of Timisoara. The research aims to evaluate the energy performance improvements and management benefits resulting from the introduction of an automated control system for the building's main installations. The study begins by outlining the fundamental principles and components of a Building Management System, emphasizing its role in monitoring, controlling, and optimizing building services such as HVAC, lighting, and electrical distribution. To quantify the benefits of BMS implementation, an energy simulation was conducted using the Vabi Elements software. Two operational scenarios were modeled: the current building configuration without a management system, and the optimized version equipped with a fully functional BMS. The simulation results indicate a substantial reduction in total energy

consumption and improved thermal comfort due to the dynamic control of HVAC systems and real-time energy management.

1. Introduction

A Building Management System (BMS) constitutes an integrated framework designed for the remote supervision and control of a building's technical installations. These systems typically encompass heating, ventilation, and air conditioning (HVAC), lighting, water distribution, electrical networks, and fire protection. Through a combination of sensors, controllers, communication protocols, and centralized management software, a BMS enables the continuous monitoring of environmental and operational parameters, ensuring that building performance aligns with both functional and comfort-related objectives.

In contemporary architectural and engineering practice, the relevance of Building Management Systems has expanded considerably due to the global imperative of reducing energy consumption and mitigating environmental impact. The building sector is responsible for approximately 40% of total energy use [1, 2], positioning it as a central focus of sustainable development policies [3, 4]. The residential sector contributes 6% to carbon dioxide emissions through energy consumption [5]. The implementation of BMS technology provides a practical and scalable solution to these challenges by facilitating energy-efficient operation, adaptive control, and predictive maintenance. Modern systems leverage advanced algorithms and data analytics to dynamically adjust operating conditions based on occupancy, climatic variations, and user behavior, thereby minimizing energy waste without compromising indoor environmental quality.

Furthermore, BMS integration serves as a foundational element in the evolution of smart buildings, which merge automation technologies with information and communication systems to achieve higher levels of performance, resilience, and user satisfaction. The proliferation of the Internet of Things (IoT), coupled with the emergence of cloud-based data management and artificial intelligence, has transformed the traditional BMS into a digital ecosystem capable of real-time optimization and remote operability [6, 7].

The application of BMS technology within student housing infrastructure is of particular importance. University dormitories represent a distinct category of residential buildings characterized by high occupancy rates, variable usage patterns, and significant energy demand variability across seasons. Ensuring optimal thermal comfort, indoor air quality, and lighting conditions for a large and dynamic population requires an integrated control approach. At the same time, universities face increasing pressure to reduce operational costs and align with sustainability objectives. Consequently, the deployment of a Building Management System in student housing offers a dual advantage: it enhances the well-being and productivity of occupants while supporting institutional commitments to energy efficiency and environmental responsibility [8].

This paper presents a case study on the integration of a Building Management System within a student housing complex located in Timișoara, Romania, managed by the West University of Timișoara. The research investigates the system's influence on energy performance, operational optimization, and occupant comfort, employing simulation-based methods to quantify the benefits of automation in a university residential context.

2. Building description and HVAC system architecture

2.1. Building description

The subject of the present study is a student housing complex situated in Timișoara, Romania, under the administration of the West University of Timișoara. The building serves as a residential facility accommodating university students and academic staff, operating continuously throughout the year. The facility has a B+GF+6F+Rf configuration, consisting of a basement, ground floor, six upper floors, and a recessed top level. The basement houses the underground parking area and several technical rooms containing the mechanical, electrical, and utility systems that serve the entire complex. The ground floor is designated for a kindergarten, representing a distinct functional zone with separate access and utilities. The first through sixth floors contain the 222 student accommodation units, designed to provide comfortable living conditions and essential amenities. The rooms are designed to accommodate 3 students, each room being equiped with its own bathroom, ensuring adequate hygiene and comfort standards for long-term residence. Each residential floor includes a shared kitchen and laundry area, facilitating daily activities and improving the quality of life for residents. The recessed floor accommodates a shared study hall and ancillary service spaces, designed to provide an environment suitable for academic activities and group work.

This vertical functional distribution ensures both operational efficiency and spatial separation between residential, educational, and technical areas. Such an arrangement presents complex energy and control requirements, making it a relevant case for the implementation and evaluation of a Building Management System capable of integrated monitoring and optimization across diverse usage zones.

2.2. HVAC system architecture

Given the mixed-use nature of the facility, which includes a kindergarten on the ground floor and student accommodation units on the upper levels, the building services were configured to operate both efficiently and independently where required. The kindergarten, located on the ground floor, is equipped with an underfloor heating system, providing uniform temperature distribution and enhanced thermal comfort for occupants, particularly suited to spaces used by children. For cooling, the kindergarten employs ceiling-mounted fan coil units, which allow for localized thermal regulation and rapid temperature adjustments. Ventilation is provided through a dedicated air handling system, fully independent from the rest of the student residence. This separation allows for autonomous operation and energy metering, ensuring precise monitoring of thermal and electrical consumption specific to this functional area. The student accommodation floors are equipped with an integrated four-pipe fan coil system embedded in the ceiling. This configuration enables simultaneous heating and cooling capability, allowing each room to maintain individual comfort conditions regardless of the season. Each dormitory room is equipped with a digital thermostat, providing occupants with local temperature control and contributing to both comfort and energy efficiency. Fresh air is supplied to the rooms through the central air handling unit (AHU) serving the entire building, which ensures a consistent supply of 30 m^3/h of fresh air per occupant, equivalent to approximately 90 m^3/h per room based on the maximum of three occupants. The exhaust of stale air is achieved through the bathrooms, which are mechanically ventilated and directly connected to the central extraction ducts. This configuration promotes balanced air circulation, maintaining indoor air quality and ensuring compliance with ventilation standards.

2.2.1. Heating station

The thermal energy for the student housing complex is supplied by a centralized plant located on the building's last floor. The heating system consists of two floor-standing condensing boilers, each rated at 650 kW, operating on natural gas. Both boilers are equipped with modulating burners, which enable variable thermal output according to instantaneous demand, thereby improving overall efficiency and reducing fuel consumption. The condensing technology allows for heat recovery from flue gases, increasing the seasonal efficiency of the system, particularly under partial load conditions. The domestic hot water (DHW) is produced by 2 heat exchangers, designed to enhance redundancy and energy efficiency. One plate heat exchanger is connected to the boiler circuit, while the second operates on the solar thermal circuit dedicated to renewable water heating. The solar installation consists of 32 evacuated-tube solar collectors, each containing 15 vacuum tubes and delivering a thermal output of approximately 1 kW per panel under nominal operating conditions. These collectors contribute significantly to preheating the domestic water, reducing the thermal load on the gas boilers during periods of favorable solar radiation. The integration of these two sources enables hybrid operation: the solar installation provides preheating during periods of sufficient solar radiation, while the boiler circuit supplements or fully covers the demand when solar energy is insufficient. The domestic hot water is stored in two buffer tanks of 5000 liters each, ensuring adequate capacity for peak demand and maintaining system stability.

2.2.2. Cooling station

The cooling demand of the building is met by a centrifugal water chiller, with a nominal cooling capacity of 1200 kW, located in the basement, accompanied by a cooling tower installed on the seventh floor, which dissipates heat from the condenser circuit to the atmosphere. This configuration minimizes noise propagation to occupied areas and optimizes space utilization within the technical zones. Both the heating and cooling hydronic networks employ variable-speed circulation pumps, which automatically adjust flow rates in response to demand, thereby improving energy efficiency and reducing electrical consumption.

2.2.3. Air handling station

Ventilation and air treatment are provided by a central air handling unit (AHU) located on the seventh floor of the building. The AHU has a total airflow rate of 38000 m^3/h and is equipped with a heat recovery system utilizing an intermediate fluid heat exchanger, designed to transfer energy between the exhaust and supply air streams. The system introduces 100% fresh outdoor air, ensuring superior indoor air quality across the building. The supply and exhaust fans are driven by motors equipped with frequency converters, allowing precise adjustment of airflow according to real-time ventilation requirements and occupancy levels.

All the thermal generation, cooling, and ventilation systems are fully integrated within the Building Management System (BMS), which ensures centralized monitoring, coordinated operation, and energy optimization. The BMS continuously tracks key operational parameters, adjusts control setpoints, and maintains a balance between energy efficiency and indoor comfort across the various functional zones of the complex. The system operates based on input data collected from a comprehensive network of field sensors and devices, including temperature sensors, pressure and differential pressure transmitters, airflow sensors, and occupancy sensors. These instruments provide real-time feedback from critical points within the HVAC, hydronic, and ventilation networks, enabling the BMS to perform adaptive control of pumps, valves, dampers, and fan speeds. Through this extensive

data acquisition infrastructure, the system is capable of predictive regulation, fault detection, and dynamic optimization of performance according to occupancy levels and climatic conditions.

3. Building Management System interface overview

The Building Management System is operated through a supervisory interface that provides facility managers with real-time access to all monitored and controlled building systems. The interface functions as the central platform through which sensor data, equipment status and alarm notifications are visualized and managed. Its primary role is to translate the complex interactions of the HVAC systems into an intuitive, structured, and operationally efficient control environment. The BMS includes several pages that enable operators to monitor and control the building's HVAC and energy systems at multiple levels of detail. Each page provides real-time information, interactive elements, and system schematics designed to enhance situational awareness and operational efficiency. The principal interface pages are described below.

3.1. Main navigation page

The main page acts as the central navigation hub for the BMS interface. It features: a floor-selection menu for accessing room-level controls, quick-access buttons to the heating station, cooling station, and AHU pages, visual branding and a building image for intuitive orientation, a system alarm icon for immediate access to critical alerts.

Figure 1. Main menu page

3.2. Room monitoring and control page

This page provides a granular overview of individual rooms, displaying real-time operational data for each accommodation unit. The interface presents each room as a tile showing: current room temperature and setpoint, operating mode (heating or cooling), occupancy status, window and door status (open/closed), presence type (student, maintenance, service), acoustic level (decibel monitoring).

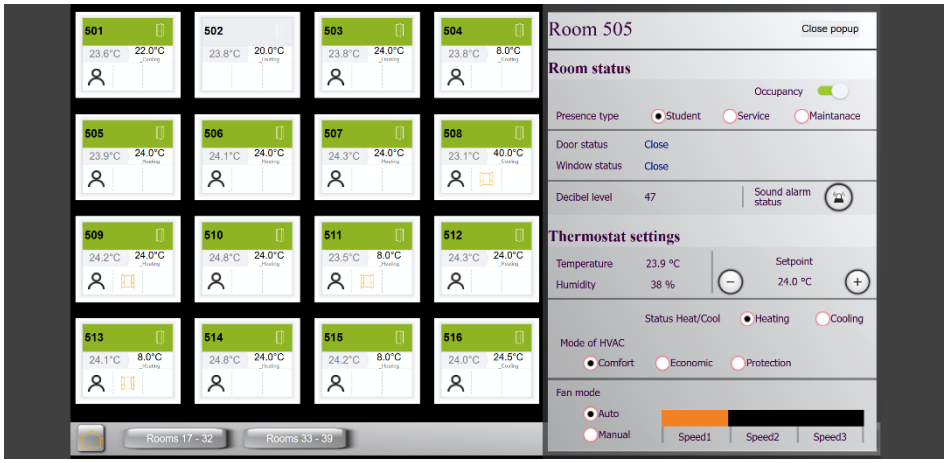


Figure 2. Room monitoring and control page

3.3. Heating station page

This interface displays the complete hydraulic diagram of the heating plant, including: condensing boilers with their operational status, primary pumps, valves, and sensors, heat exchangersfor the domestic hot water (DHW) system, solar thermal circuit integration, thermal storage tanks (5,000 L each), temperature and pressure values across all main circuits.

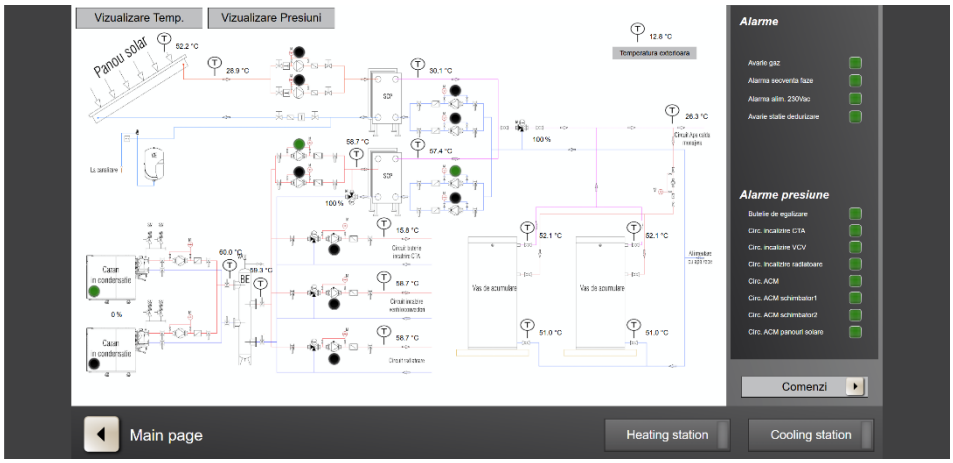


Figure 3. Heating station page

3.4. Cooling station page

The cooling station page illustrates the operation of the 1200 kW centrifugal chiller, the cooling tower, and the associated hydraulic circuits. It presents the chilled-water supply and return temperatures, condenser-water flow and temperature, compressor operational status, pump pressures and flow conditions, cooling tower fan modulation, interaction with the low-temperature circuits serving the AHU and fan coil units.

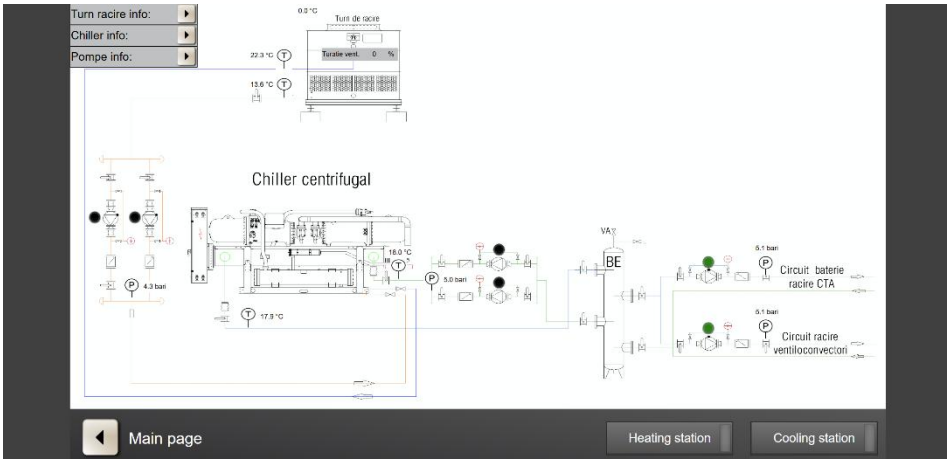


Figure 4. Cooling station page

3.5. Air handling unit (AHU) page

The AHU page shows the configuration of the 100% outdoor air ventilation unit, including: outdoor-air temperature, supply and return airflow rates, heating coil and cooling coil operation, heat recovery system based on intermediate fluid, fan speeds driven by variable-frequency drives, supply and extract air temperatures.

Figure 5. Air handling unit page

4. Building energy simulation using Vabi Elements

To evaluate the impact of the Building Management System (BMS) on the energy performance and indoor environmental quality of the student housing complex, a comprehensive building energy simulation was conducted using the Vabi Elements software package. This simulation environment enables a detailed analysis of dynamic energy flows, comfort parameters, and system interactions within buildings, under varying climatic and operational conditions. Vabi Elements is a professional-grade simulation platform developed to support the design and optimization of energy-efficient buildings. It allows for the modeling of heating, cooling, ventilation, and domestic hot water systems, as well as lighting and occupancy schedules. The software operates on a multizone thermal model, considering both transient heat transfer through the building envelope and the dynamic response of HVAC systems to external and internal loads. It incorporates hourly weather data, material thermal properties, and system characteristics to estimate annual energy consumption, peak loads, and comfort indicators such as air temperature and operative temperature. The building geometry, materials, and HVAC configurations were modeled based on the actual architectural and technical specifications

of the facility. Internal gains from occupants, lighting, and equipment were included according to standard residential and educational building profiles.

Two distinct operational scenarios were developed to quantify the influence of BMS integration: scenario 1, baseline (without BMS), scenario 2, optimised (with BMS).

The comparison between these two scenarios allows for a quantitative assessment of the energy efficiency improvements and comfort enhancements achieved through automation. Key performance indicators analyzed in the simulation include annual heating and cooling energy consumption, electrical usage for auxiliary systems, thermal comfort indices, and system utilization efficiency.

4.1. Scenario 1, baseline, without BMS

In this configuration, the building systems operate independently, without centralized control or dynamic adjustment. The HVAC systems function based on fixed temperature setpoints and manual operation schedules. The ventilation rate is constant, without modulation according to occupancy or indoor air quality. Lighting operates on static schedules, without daylight or presence-based control. This scenario represents the conventional, non-automated operation of the building.

Table 1. Energy simulation results, Scenario 1, without BMS

Building name	*Total energy use* [kWh/year]	*Specific energy use* [kWh/m²/year]	*Specific CO_2 emission* [kg/m²/year]	*Total costs energy use* [€/year]	*Specific costs energy use* [€/m²/year]
Student housing complex	555955.12	49.83	24.71	58159.00	5.21
Heating	165387.61	14.82	2.47	10823.80	0.97
Domestic Hot Water	228741.46	20.50	3.41	14969.99	1.34
Cooling	44789.97	4.01	5.21	8957.99	0.80
Fans, pumps and controls	23373.32	2.10	2.72	4674.66	0.42
Lighting	93662.77	8.40	10.90	18732.55	1.68

4.2. Scenario 2, optimised, with BMS:

In this scenario, the building operates under the supervision of a fully integrated Building Management System. The BMS dynamically adjusts temperature setpoints, airflow rates, and equipment operation in response to real-time sensor data and occupancy levels. Ventilation is demand-controlled, based on CO_2 concentration and presence detection. Heating and cooling outputs are modulated to maintain optimal comfort conditions while minimizing energy use. Lighting control integrates both occupancy sensors and daylight harvesting functions. In addition, the BMS coordinates the operation of the boilers, chiller, and pumps through variable-speed drives, ensuring that energy generation matches the actual load requirements.

Table 2. Energy simulation results, Scenario 2, with BMS

Building name	*Total energy use* [kWh/year]	*Specific energy use* [kWh/m²/year]	*Specific CO_2 emission* [kg/m²/year]	*Total costs energy use* [€/year]	*Specific costs energy use* [€/m²/year]
Student housing complex	538313.78	48.25	19.35	50242.25	4.50
Heating	198002.37	17.75	2.95	12958.27	1.16
Domestic Hot Water	228741.46	20.50	3.41	14969.99	1.34
Cooling	31608.80	2.83	3.68	6321.76	0.57
Fans, pumps and controls	23373.32	2.10	2.72	4674.66	0.42
Lighting	56587.85	5.07	6.58	11317.57	1.01

5. Results and discussion

Table 3. Comparison between energy simulation result

Building name	*Total energy use* [MWh/year]		*Specific energy use* [kWh/m²/year]		*Specific CO_2 emission* [kg/m²/year]		*Total costs energy use* [k€/year]		*Specific costs energy use* [€/m²/year]		*Improvements [%]*
	No BMS	*With BMS*	*No BMS*	*With BMS*	*No BMS*	*With BMS*	*No BMS*	*With BMS*	*No BMS*	*With BMS*	
Student housing complex	555.95	538.31	49.93	48.25	24.71	19.35	58.16	50.24	5.21	4.50	+3.17
Heating	165.38	198.00	14.82	17.75	2.47	2.95	10.82	12.95	0.97	1.16	-19.72
DHW	228.74	228.74	20.50	20.50	3.41	3.41	14.97	14.97	1.34	1.34	0.00
Cooling	47.78	31.60	4.01	2.83	5.21	3.68	8.95	6.32	0.80	0.57	+29.43
Fans, pumps and controls	23.37	23.37	2.10	2.10	2.72	2.72	4.67	4.67	0.42	0.42	0.00
Lighting	93.66	56.58	8.4	5.07	10.90	6.58	18.73	11.31	1.68	1.01	+39.58

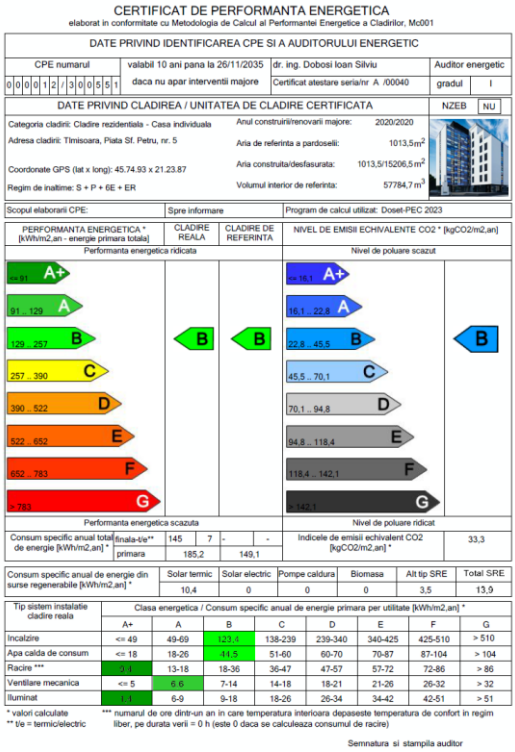
A notable outcome of the simulation is the increase in annual heating energy demand in the BMS-operated scenario compared to the baseline case, despite a measurable reduction in the building's total primary energy consumption. Although counterintuitive at first glance, this behavior is consistent with the underlying thermodynamic and operational conditions imposed by the building's ventilation and control strategy.

The building is equipped with an air-handling unit (AHU) that supplies 100% outdoor air with no recirculation component, meaning that all supply air must be heated from ambient outdoor conditions to the required supply temperature during the heating season. In the baseline (non-BMS) scenario, ventilation operation is typically less consistent and often subject to under-ventilation during certain periods, either due to manual intervention, suboptimal scheduling, or waning performance of uncontrolled systems. As a result, the effective outdoor-air load may be lower than the design requirement. Under BMS supervision, however, the ventilation system is regulated more rigorously.

The BMS maintains design-compliant outdoor airflow rates, often modulated dynamically based on occupancy schedules, CO_2 concentration thresholds, or indoor air quality requirements. This leads to a more continuous and accurate fulfillment of ventilation needs. Because the AHU operates exclusively with fresh air, adherence to proper ventilation rates inherently increases the volume of cold outdoor air that must be thermally conditioned, thereby elevating the heating demand.

Furthermore, the implementation of the BMS substantially reduces internal heat gains, particularly from lighting and possibly from more efficient equipment cycling. Although LED luminaires produce less waste heat per unit of light output compared to conventional sources, the significant reduction in lighting energy consumption on the order of ~37 MWh/year still translates into a meaningful decrease in the internal thermal gains that previously contributed passively to space heating. With these gains removed or diminished, the HVAC system must supply a greater portion of the heating load to maintain the same comfort conditions.

Additionally, BMS-controlled spaces exhibit tighter temperature regulation, reducing both overheating and underheating. While this improves thermal comfort and stabilizes indoor conditions, it also prevents the occasional temperature drift below setpoint that often occurs in non-controlled buildings, where such drift incidentally lowers heating demand. Maintaining temperatures closer to comfort setpoints throughout occupancy periods therefore results in a higher, but more accurate and comfort-driven, heating load. However, this rise is effectively offset by substantial decreases in cooling and lighting energy, yielding an overall improvement in building energy performance, operational efficiency, and indoor environmental quality. Finally, the simulation results, along with the conclusions, are supported by the building`s Energy Performance Certificate (EPC). The EPC places the building in line with the reference used by the local romanian calculation methodology (Mc001/2022).



CERTIFICAT DE PERFORMANTA ENERGETICA

elaborat in conformitate cu Metodologia de Calcul al Performantei Energetice a Cladirilor, Mc001

DATE PRIVIND IDENTIFICAREA CPE SI A AUDITORULUI ENERGETIC

CPE numarul	valabil 10 ani pana la 26/11/2035	dr. ing. Dobosi Ioan Silviu	Auditor energetic
0 0 0 0 1 2 / 3 0 0 5 5 1	daca nu apar interventii majore	Certificat atestare seria/nr A /00040	gradul I

DATE PRIVIND CLADIREA / UNITATEA DE CLADIRE CERTIFICATA — NZEB: NU

Categoria cladirii: Cladire rezidentiala - Casa individuala	Anul construirii/renovarii majore:	2020/2020
Adresa cladirii: Timisoara, Piata Sf. Petru, nr. 5	Aria de referinta a pardoselii:	1013,5m²
Coordonate GPS (lat x long): 45.74.93 x 21.23.87	Aria construita/desfasurata:	1013,5/15206,5 m²
Regim de inaltime: S + P + 6E + ER	Volumul interior de referinta:	57784,7 m³

Scopul elaborarii CPE:	Spre informare	Program de calcul utilizat: Dosel-PEC 2023

PERFORMANTA ENERGETICA * [kWh/m2,an - energie primara totala]	CLADIRE REALA	CLADIRE DE REFERINTA	NIVEL DE EMISII ECHIVALENTE CO2 * [kgCO2/m2,an]	
Performanta energetica ridicata			Nivel de poluare scazut	
<= 91 A+	B	B	<= 16,1 A+	B
91 .. 129 A			16,1 .. 22,8 A	
129 .. 257 B			22,8 .. 45,5 B	
257 .. 390 C			45,5 .. 70,1 C	
390 .. 522 D			70,1 .. 94,8 D	
522 .. 652 E			94,8 .. 118,4 E	
652 .. 783 F			118,4 .. 142,1 F	
> 783 G			> 142,1 G	
Performanta energetica scazuta			Nivel de poluare ridicat	

Consum specific anual total de energie [kWh/m2,an] *					Indicele de emisii echivalent CO2 [kgCO2/m2,an] *	33,3
	finala-tie**	145	7	-	-	
	primara	185,2		149,1		

Consum specific anual de energie din surse regenerabile [kWh/m2,an] *	Solar termic	Solar electric	Pompe caldura	Biomasa	Alt tip SRE	Total SRE
	10,4	0	0	0	3,5	13,9

Tip sistem instalatie cladire reala	Clasa energetica / Consum specific anual de energie primara per utilitate [kWh/m2,an] *							
	A+	A	B	C	D	E	F	G
Incalzire	<= 49	49-69	123,4	138-239	239-340	340-425	425-510	> 510
Apa calda de consum	<= 18	18-26	44,5	51-60	60-70	70-87	87-104	> 104
Racire ***	0,3	13-18	18-36	36-47	47-57	57-72	72-86	> 86
Ventilare mecanica	<= 5	6-6	7-14	14-18	18-21	21-26	26-32	> 32
Iluminat	0,3	6-9	9-18	18-26	26-34	34-42	42-51	> 51

* valori calculate
** tie = termic/electric
*** numarul de ore dintr-un an in care temperatura interioara depaseste temperatura de confort in regim liber, pe durata verii = 0 h (este 0 daca se calculeaza consumul de racire)

Semnatura si stampila auditor

Figure 6. Energy Performance Certificate, according to the romanian methodology Mc001/2022

6. Conclusion

The integration of a Building Management System within the student housing complex operated by the West University of Timișoara demonstrates the significant potential of advanced automation technologies to enhance energy efficiency, operational performance, and indoor environmental quality in contemporary educational buildings. The facility's complex functional layout presents diverse and dynamic thermal, ventilation, and occupancy profiles. These characteristics make the building an exemplary case study for evaluating the benefits of coordinated and intelligent building control.

The dynamic energy simulation conducted with Vabi Elements provided a quantitative perspective on the contribution of the BMS to the building's performance. By modeling both a baseline scenario without automation and a BMS-enabled scenario with optimized control strategies, the simulation highlighted measurable improvements in annual energy consumption. Although the heating demand increased due to enhanced ventilation accuracy, tighter temperature regulation, and reduced internal heat gains from lighting, the overall energy balance favored the BMS scenario. Significant reductions in cooling and lighting energy consumption resulted in a net decrease in total annual energy use, confirming that centralized automation supports not only improved comfort but also meaningful energy savings. These outcomes correspond with current trends in building performance science, where intelligent control is recognized as a key contributor to reducing operational energy consumption in high-occupancy, mixed-use facilities. Furthermore, the BMS supervisory interface demonstrated the value of real-time monitoring and intuitive visualization tools for building operation. Detailed schematics of the heating plant, cooling system, AHU, and room-level controls allow facility managers to diagnose issues promptly, adjust system parameters, implement scheduling strategies, and maintain compliance with comfort and air-quality requirements. Such transparency and ease of operation reinforce the role of BMS platforms as essential components in modern building management.

Overall, the study confirms that the implementation of a Building Management System in this student housing complex enhances system coordination, energy performance, and occupant comfort. The findings underscore the importance of adopting intelligent automation in institutional buildings, particularly those with diverse functional zones and significant ventilation loads. By integrating advanced control strategies, sensor networks, and energy monitoring capabilities, the BMS contributes to more sustainable facility operation and provides a robust foundation for future optimization and data-driven energy management initiatives.

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