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Energy Audit of the Faculty of Science and Technology's Building at the University of Kinshasa in the Democratic Republic of the Congo

Sharon Tshibola Mpiana[1,5], Bernard Ndaye Nkanka[4,5], Thierry Tangou Tabou[1,6], Haddy Mbuyi Katshiatshia[2], Guerschom Lutumba Mbunzu[3], Eric Kayembe Kasongo[4,5], Elisée Mulongo Kapala[4,5]

[(1)]University of Kinshasa. Faculty of Science and Technology. Department of Environmental. BP 190 Kinshasa XI (DRC). Email: sharon.tshibola@unikin.ac.cd
[(2)]University of Kinshasa. Polytechnic Faculty. BP 190 Kinshasa XI (DRC)
[(3)]University of Kinshasa. Faculty Of Science and Technology. Department of Mathematics and Computer Science. BP 190 Kinshasa XI (DRC)
[(4)]Higher Institute of Applied Technology. BP 6593 - Kinshasa 31 (DRC)
[(5)]Kitsisa Khonde Center for Studies and Research on Renewable Energy Kinshasa. BP 6593 Kinshasa 31 (DRC)
[(6)]Kinshasa Regional Center for Nuclear Studies. BP 190 Kinshasa XI (DRC)

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ABSTRACT

Description of the subject. In tropical countries such as the Democratic Republic of the Congo, the failure of building envelopes to adapt to the local climate leads to excessive energy consumption, primarily due to air conditioning and lighting ; it also exacerbates the building's environmental impact.
Objective. This study aims to analyze the building's actual energy consumption, identify sources of inefficiency, and propose improvement measures tailored to the local climate.
Methods. The methodology adopted is based on a detailed energy audit that includes an analysis of consumption patterns, an assessment of the building envelope, a study of indoor comfort, and the identification of energy-intensive equipment.
Results. The results highlight several areas for optimization that could significantly reduce energy consumption while improving comfort levels.
Conclusion. Implementing the proposed improvement measures will reduce the building's total energy consumption which currently stands at 364,386 kWh/year and amounts to 107,278,882 CDF (excluding VAT) by 23 %, and will also improve the building's environmental performance.

Keywords: Rnergy audit, energy efficiency measures, energy savings, Faculty of Science and Technology, Kinshasa/DRC.

RESUME

Audit énergétique du bâtiment de la faculté des Sciences et Technologies de l'Université de Kinshasa, République Démocratique du Congo
Description du sujet. Dans les pays tropicaux comme la République Démocratique du Congo, le manque d'adaptation de l'enveloppe du bâtiment au climat local entraîne une consommation énergétique excessive, principalement due à la climatisation et à l'éclairage ; accentue aussi l'empreinte environnemental du bâtiment.
Objectif. Cette étude vise à analyser la consommation énergétique réelle du bâtiment, d'identifier les sources d'inefficacité et de proposer des mesures d'amélioration adaptées au contexte climatique local.
Méthodes. La méthodologie adoptée repose sur un audit énergétique détaillé incluant l'analyse des profils de consommation, l'évaluation de l'enveloppe du bâtiment, l'étude du confort thermique intérieur ainsi que l'identification des équipements énergivores.
Résultats. Les résultats obtenus mettent en évidence plusieurs axes d'optimisation susceptibles de réduire significativement la consommation énergétique tout en améliorant les conditions de confort.
Conclusion. La mise en œuvre des mesures d'amélioration proposées permettent de réduire de 23 %, la consommation énergétique globale du bâtiment qui s'élève à 364 386 kWh/an et représente un coût de 107 278 882CDF HTVA ; et aussi améliorer la performance environnementale du bâtiment.

Mots-clés : Audit énergétique, mesures d'efficacité énergétique, économies d'énergie, Faculté des Sciences et Technologies, Kinshasa/RDC.

1. INTRODUCTION

The Industrial Revolution led to a significant increase in the use of energy resources, the extraction and conversion technologies of which drive the development of every country (Younes, 2020) and improve people's living conditions (Kaoutar, 2017) but are also a major source of greenhouse gas emissions(GHG), dramatically affecting the planet's future by disrupting its climate system (Conze, 2018). It is virtually certain that, in most continental regions, heat waves will become more frequent and cold spells less frequent on a daily and seasonal basis as the global average temperature rises. It is very likely that heat waves will become more frequent and last longer that heat waves will become more frequent and last longer (IPCC, 2013).

Policies aimed at reducing energy consumption across various sectors are credible pathways to achieving the goal of net-zero carbon emissions. Given that the building sector alone accounts for 30 % of GHG from heating, cooling, and lighting, it stands as a key player in addressing the pressing environmental challenges we face. It may well be the only sector offering sufficient potential for progress to meet the various commitments (UNEP, 2024).

Currently, 40 % of the world's population lives in the intertropical belt. By 2060, this share will reach 60 %. Greenhouse gas emissions (GHG) from countries in the tropical zone are projected to at least quadruple by 2030 compared to 2000 levels, according to established baseline cenarios. The intertropical zone is also facing unprecedented urbanization (EEMA, 2019).

Most new buildings (both residential and commercial) located in cities Tropical buildings are constructed without taking the local climate into account. This results in excessive energy consumption (air conditioning) to offset the discomfort caused by the heat (EEMA, 2019). All studies conducted on the building stock in urban areas across African countries show that these buildings are poorly adapted to their climatic environment. Most buildings found in African cities are made of concrete and glass, as in temperate countries, and act as veritable greenhouses, requiring significant air conditioning to remove the heat they generate and ensure the comfort of occupants. In the DRC, the building sector accounts for 80 % of final energy consumption (IEA, 2021).

All of these reasons call for a different approach to the design of new buildings, which will be energy-efficient, make effective use of the renewable energy source (sun, wind, geothermal) available to them, utilize local materials while boosting the local economy, and be resilient enough to adapt to the effects of climate change (FISD, 2015).

The DRC's construction sector is challenged by climate-inappropriate materials that degrade thermal comfort and inflate energy demands. Auditing existing infrastructure is therefore crucial for identifying cost-effective energy savings and improving envelope performance. Accordingly, this research project audits an institutional building to optimize its overall energy and environmental footprint.

This project was of paramount importance because it sets a milestone in the field of energy auditing in the DRC; it stands as the first initiative to assess the energy and environmental performance of a building particularly an institutional one and serves as a benchmark for all researchers. Furthermore, the proposed improvement solutions present real opportunities for the management committee in general to achieve significant financial savings if implemented across all faculties, and for the authorities of the Faculty of Science and Technology in particular.

2. MATERIAL AND METHODS

2.1. Study Site

The Faculty of Science and Technology building at the University of Kinshasa (UNIKIN) is located in the municipality of Lemba, southwest of the city of Kinshasa in the Democratic Republic of the Congo (DRC). The region is characterized by an Aw4 climate, according to the Köppen classification, which is a humid tropical climate where the average minimum temperatureremains above 18 °C. Figure 1 illustrates the building's geographic location.

Figure 1. Location of the Faculty of Science and Technology building/UNIKIN (GoogleMaps)

As shown in Figure 1, the building is located at 4°25' south latitude, 15°18' east longitude, and an average elevation of 443 meters. It is bordered to the north by the administrative building, to the south by the Faculty of Pharmaceutical Sciences, to the east by the Polytechnic Faculty, and to the west by the Kinshasa Regional Center for Nuclear Studies (CREN-K).

2.2. Methods

The data collected comes from the energy usage inventory (air conditioning, lighting, office and laboratory equipment), an inspection of the building envelope, measurements of CO_2, temperature, and relative humidity of the indoor air, and the building's total energy consumption at the medium-voltage/low-voltage substation.
The data analysis was accompanied by simulation within the EDGE Building interface to establish a baseline energy consumption figure to be used as a benchmark for the improvement scenarios. These scenarios must yield at least a 20 % energy savings in accordance with the software's energy efficiency standard.

Inspection of the Building Envelope

The types of materials comprising the building envelope were identified. Next, samples were taken from the surfaces of the walls and windows (including their number) by orientation (North, South, East, and West). This data was used to determine the building's Window to Wall Ratio (WWR), which is a very important parameter :
Equation 1

$$\mathbf{WWR} = \frac{\mathbf{Window\ surface\ area(sq.m.)}}{\mathbf{Gross\ exterior\ wall\ area\ (sq.m.)}} \boldsymbol{x100}$$

Source : EDGE Buildin

Assessment of occupant comfort

Comfort is a key factor in occupant well-being. It was assessed based on three parameters : CO_2, temperature, and relative humidity.

Load Inventory

The quantity and power rating of energy-consuming loads were recorded by category, including air conditioning, lighting, office equipment, as well as laboratory and technical room equipment. Based on these data, the building's peak demand and annual energy consumption were determined. Additionally, a power analyzer was used to measure energy consumption at the building's medium-voltage/low-voltage (MV/LV) transformer substation (Figure 2).

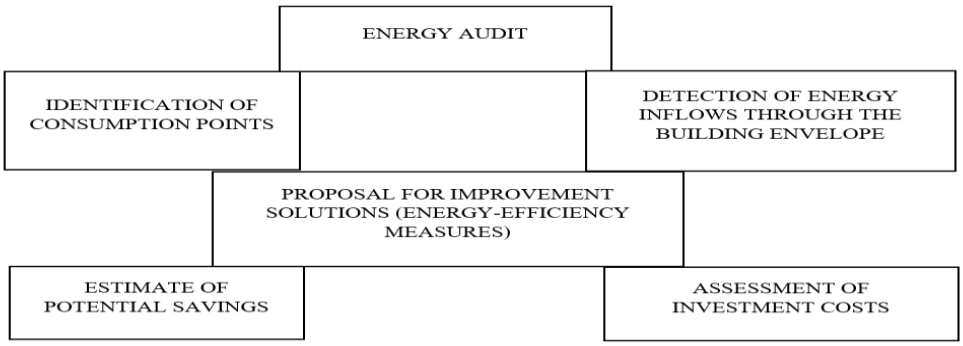
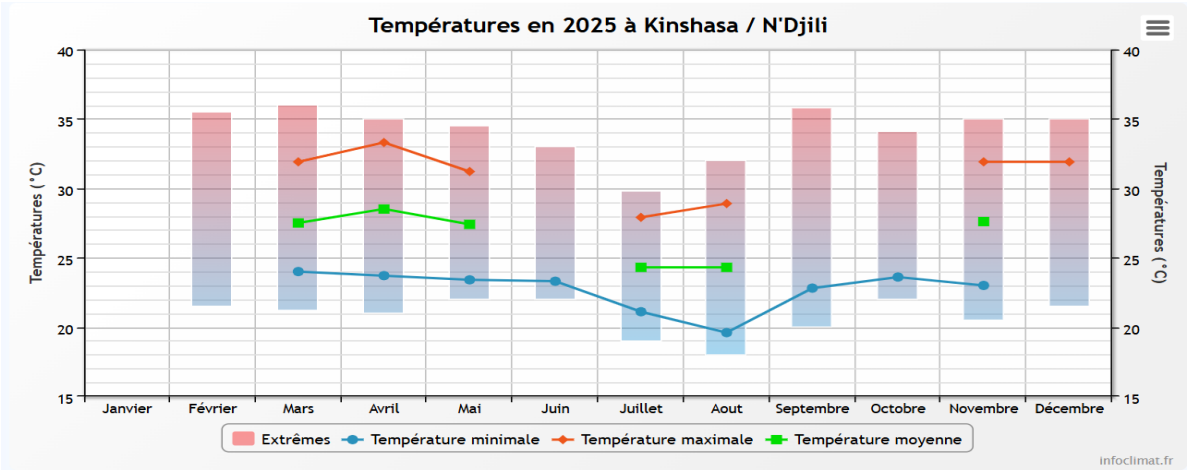


Figure 2. Structure of the energy audit

3. RESULTS AND DISCUSSION

3.1. Climate data for the N'Djili station, Kinshasa

The figure 3 illustrates the climate data for the N'Djili station in Kinshasa.



Source : infoclimat.fr

Figure 3. Temperature trends in the city of Kinshasa during the year 2025

The climate of the city of Kinshasa is hot year-round, with a small annual temperature range, typical of a tropical climate (Aw). Maximum temperatures range from 30 to 36 °C, average temperatures are between 24 and 29 °C, and minimum temperatures are slightly below 20 °C. The hottest months are March, April, May, September, October, November, and December, when maximum temperatures reach up to 36 °C and average temperatures hover around 29 °C. Conversely, the relatively cooler months are June, July, and August, with minimum temperatures ranging from 19–21 °C and average temperatures between 24–25 °C.

3.2. Building Description

The building is rectangular in shape with a total floor area of 15,561.37 m². It comprises: 118 offices, 16 laboratories, 30 lecture halls, 3 meeting rooms, 6 administrative offices, 1 herbarium, 1 administrative office, 2 open-plan areas, 1 accounting office, 8 restrooms, 1 library, and 2 technical rooms.

The building is a tertiary institutional structure built in 1954, featuring reinforced concrete, large bay windows, massive columns, and a flat roof. It has simple, functional facades and concrete staircases. It is distinguished by continuous balconies and corridors that open to the outside.

3.3. Assessment of the Building Envelope

Roof

The figure 4 shows an aerial view of the roof of the Faculty of Science and Technology at the University of Kinshasa.

Figure 4. View of the roof of the Faculty of Science and Technology

The roof is the part of the building envelope where nearly 70 % of solar heat gain occurs (Enviro – BAT, 2019). The roof of the audited building is flat and dark in color, and because of its high absorption coefficient, it contributes to heat gain within the building.

Walls

The figure 5 illustrates the exterior walls of the audited building.

Figure 5. View of the exterior walls of the audited building

The walls are constructed of concrete characterized by high thermal inertia, an emissivity ($\varepsilon = 0.9$), and a thermal conductivity ($\lambda = 1$ to 2 W/m·K), according to (Pajani, 2012). Certain wall surfaces are painted in dark colors ; these possess high solar absorbance coefficients, which promote significant heat gain.

Table 1. Wall area

Wall	Basement		Ground floor		First floor		orientation	Wall surface (sq. ft.)
	length	height	length	height	length	height		
1	217,00	3,70	164,00	3,60	164,00	3,60	North	1983,70
2	166,00	3,70	141,00	3,60	141,00	3,60	East	1629,40
3	177,00	3,70	181,00	3,60	181,00	3,60	South	1958,10
4	159,00	3,70	171,00	3,60	171,00	3,60	West	1819,50

Source : Table compiled internally based on collected data.

This table shows that the total wall area is 7,390.70 sq.ft, distributed as follows: the north and south facades are larger, at 1,983.70 sq.ft and 1,958.10 sq.ft respectively, than the west and east facades, which measure 1,819.50 sq.ft and 629.40 sq.ft respectively.

Glazing

The view of the audited building's windows is presented in Figure 6.

Figure 6. View of the windows of the building under audit

The building’s windows consist of single-pane glass (U-value = 0.86) in three different sizes:

Table 2. Window dimensions

Types of Windows	Dimensions
W-1	L= 1, 40m ; h= 0,83 m
W-2	L= 1, 10m ; h= 0,80m
W-3	L= 1, 90m ; h= 0,83 m

Source: Table compiled internally based on collected data

This table shows that the windows are very large, which often results in heat gain, raises the indoor temperature, and reduces the building's comfort.

Figure 7. Combined sun protection systems of the audited

Figure 8. Combined sun protection systems

The windows feature combined sunshades (egg-box style) that are suited to the local climate but made of concrete (a material with high thermal mass).

Number and area of the windows

The number and area of windows are presented in Table 3 below.

Table 3. Number and area of windows

TYPE	Basement Windows				Ground-floor windows				First-floor windows				orientation	glass surfaces
	L	H	S	Nbr	L	H	S	Nbr	L	H	S	Nbr		
F-1	1,40	0,83	1,16	122									North	141,76
F-3					1,90	0,83	1,58	131,00	1,90	0,83	1,58	149		441,56
Total glazed area in sq.ft.														**583,32**

TYPE	Vitrage Sous-sol				Vitrage Rez de chaussée				Vitrage premier étage				orientation	glass surfaces
	L	H	S	Nbr	L	H	S	Nbr	L	H	S	Nbr		
F-1	1,40	0,83	1,16	50									East	58,10
F-3					1,90	0,83	1,58	48	1,90	0,80	1,52	1		77,22
														0,00
Total glazed area in sq.ft.														**135,32**

TYPE	Basement windows				Ground-floor windows				First-floor windows				orientation	glass surfaces
	L	H	S	Nbr	L	H	S	Nbr	L	H	S	Nbr		
F-1	1,40	0,83	1,16	94									South	109,23
F-3					1,90	0,83	1,58	99	1,90	0,83	1,58	24		193,97
Total glazed area in sq.ft.														**303,20**

TYPE	Basement windows				Ground-floor windows				First-floor windows				orientation	glass surfaces
	L	H	S	Nbr	L	H	S	Nbr	L	H	S	Nbr		
F-1	1,40	0,83	1,16	46									West	53,45
F-2	1,10	0,80	0,88	14	1,90	0,83	1,58	73	1,90	0,83	1,58	78		250,45
Total glazed area in sq.ft.														**303,90**

Source : Table compiled internally based on collected data

This table shows that the building has a total of 929 windows and a total glazed area of 1,325.738 m².

Glazing ratio

The glazing ratio is presented in Table 4.

Table 4. Glazing ratio

Ratio of glazing to wall area

Wall	Surface (sq.ft.)		% Glazing	Orientation
	Gross	Glazed		
1	1983,70	583,32	29%	North
2	1629,40	135,32	8%	East
3	1958,10	303,20	15%	South
4	1819,50	303,90	17%	West
Total	**7390,70**	**1325,738**	**18%**	

Source : Table compiled internally based on collected data

This table shows that the total wall area is 7,390.70 m², the glazed area is 1,325.74 m², and the glazing ratio by orientation is 29 % on the north, 8 % on the east, 15 % on the south, and 17 % on the west. Consequently, the glazing ratio for the entire building is 18 %.

3.4. Assessment of occupant comfort

Comfort is a key factor in occupant well-being and productivity. Therefore, three parameters CO_2 levels, temperature, and relative humidity were used to assess the level of comfort in the building (Table 5).

Table 5. Daily averages of CO_2, temperature, and relative humidity

Days	CO_2 (ppm)	T(°C)	Hr (%)
Apr 28, 2025	409	32	66
Apr 29, 2025	411	32	75
Apr 30, 2025	410	30	81
May 1, 2025	411	31	78
May 2, 2025	409	31	73
May 4, 2025	411	32	62
May 5, 2025	411	31	67
May 6, 2025	411	32	64
May 7, 2025	411	32	68
May 8, 2025	410	32	72

Source : Table compiled internally based on collected data

After assessing comfort levels, the average CO_2 concentration is 410 ppm. According to standard NF EN 13779, 2007 (Ventilation in non-residential buildings Performance requirements for ventilation and air-conditioning systems), the recommended indoor CO_2 level in offices, classrooms, and meeting rooms must be below 600 ppm.

The average temperature inside the building is 32 °C. According to the standard NF EN 15251: 2007 (Indoor environmental criteria for the design and evaluation of the energy performance of buildings covering indoor air quality, thermal comfort, lighting, and acoustics), the recommended temperature ranges for cooling in offices and similar spaces (individual or open-plan offices, meeting rooms, auditoriums, cafeterias, restaurants, classrooms) must be between 23 and 26 °C. Furthermore, there is a relationship between the standard effective temperature (SET) and perceived comfort. This relationship explains why a sedentary person in a temperature range of 30–34 °C is in a physiological state of sweating and experiences a sensation of heat that is uncomfortable and unacceptable. The average humidity level measured in the building is 71%. According to ASHRAE, 2019 (Humidity and Mold – Applications), the comfort zone in a building is between 40 % and 60 %.

3.5. Overview of Energy Consumption

The table 6 illustrates the overview of energy uses.

Table 6. Overview of Energy Uses

n°	Description of charge groups	Peak Deamand (kW)	%	Energy Consumption (kWh)	%
1	Air conditioning	103	47 %	290 685	79,8 %
2	Office equipment	58	26 %	11 624	3,2 %
3	lighting	2	1 %	51 626	14,2 %
4	laboratory and technical room equipment	58	26 %	10 451	2,9 %
	Total for installation	**221**	**100 %**	**364 386**	**100 %**

After analyzing the energy consumption, the building's annual consumption is 364,386 kWh, or 364 MWh, and the peak demand is 221 kW. In fact, air conditioning is the most energy-intensive category, consuming 290,685 kWh/year, followed by lighting at 51,626 kWh/year, office equipment at 11,624 kWh/year, and laboratory and technical room equipment at 10,451 kWh/year. Air conditioning accounts for the vast majority of energy consumption, representing 47 % of peak demand and consuming 79.8 % of total energy. This indicates intensive use of air conditioning, which is a potential area for optimization. Office equipment has a high peak demand of 26 % but very low consumption at 3.2 %.

It has a negligible impact on overall consumption, indicating equipment with limited use. Lighting (primarily fluorescent lamps) accounts for 1 % of peak demand but consumes 14.1 % of total energy. This is relatively proportionate, but it indicates a relatively long usage time, potentially an area for optimization by replacing the existing, less efficient technology with high-efficiency, low-consumption alternatives. Laboratory and technical room equipment has a peak demand of 26 % but consumes only 2.9 % of total energy. This may indicate high-power equipment that is used intermittently. Thus, air conditioning is clearly the biggest energy consumer, followed by lighting; optimizing these two areas will help significantly reduce the building's overall energy consumption.

Profile Analysis

Since the load is not distributed at the MV/LV substation, the recorded energy consumption is aggregate. The recording began on April 28, 2025, and ended on May 8, 2025, covering a period of 10 days (Figure 9).

Power

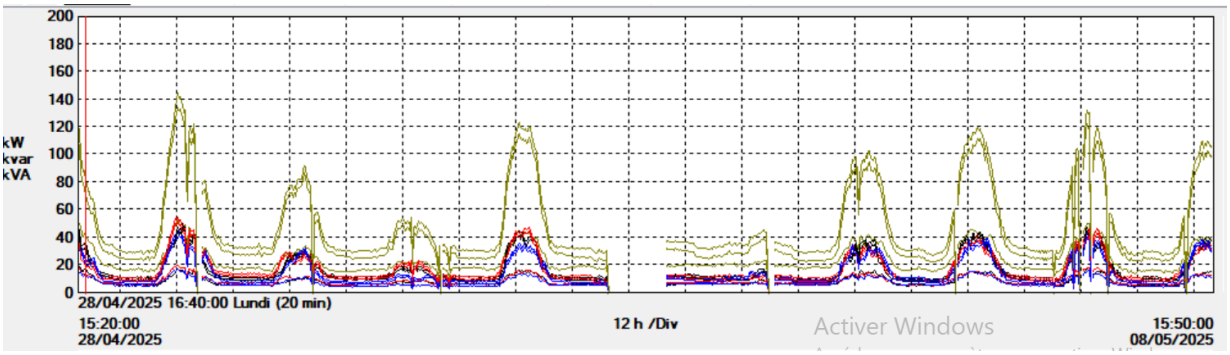


Figure 9. Power profile

The power profile analysis defines two time periods: the first is from 8:00 a.m. to 7:00 p.m., and the second is from 7:00 p.m. to 8:00 a.m. Starting on April 29, 2025, it was observed that at 8:00 AM, power consumption was 38.29 kW; it rose sharply around 11:50 AM to approximately 129.4 kW, then dropped to 46.17 kW around 7:30 PM. It decreased during the night, when values were around 28 kW, and the trend remained the same throughout the ten-day recording period.

The graph shows that energy consumption during the evening hours (7:00 p.m. to 8:00 a.m.) is lower than during the day but remains significant. This indicates that some equipment remains in operation overnight (Table 7). By identifying and turning off this non-essential equipment, it is possible to further reduce energy consumption and the associated costs.

Table 7. Time-of-use energy consumption

Période	Time slot	Average power (kW)	Comments
Day	8:00 AM - 7:00 p.m	89,74 kW	At peak activity, the equipment is in use.

Evening	7:00 p.m -8:00 AM	26,03 kW	Reduced activity, but significant consumption.

Source : Table created in-house based on collected data

It is recommended to : (i) Turn off the air conditioning and lights when leaving the room for good ; (ii) Put office equipment on standby or turn it off.

Energy

The figure 10 illustrates the energy profile.

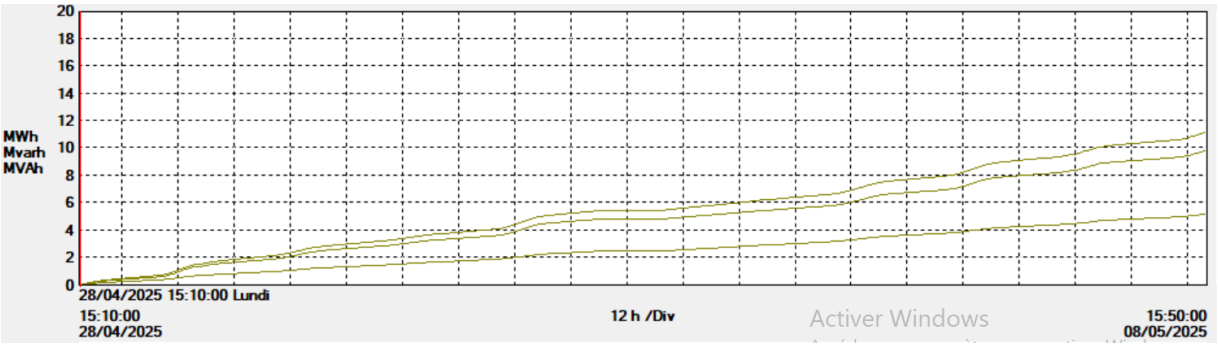


Figure 10. Energy Profile

The energy consumption recorded over these ten days was 9.847 MWh. Based on this data, the building's annual energy consumption was determined; it is 359.415 MWh, or 359 MWh. Consequently, the building's recorded energy consumption is 359 MWh/year, and the consumption derived from the equipment inventory is 364 MWh/year.

Correlation between energy consumption and changes in indoor temperatures

The figure 11 illustrates the correlation between energy consumption and changes in indoor temperatures.

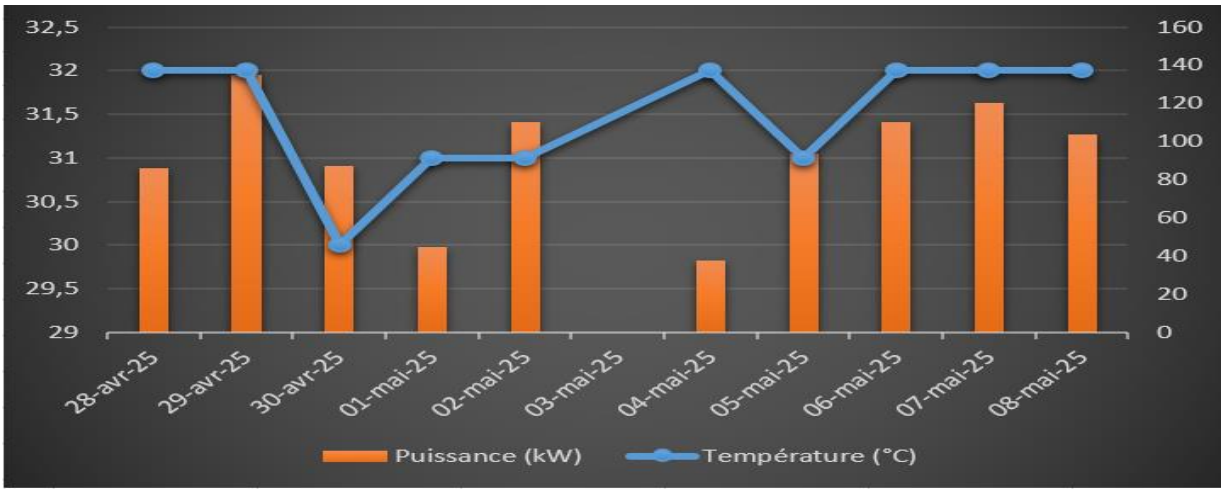


Figure 11. Correlation between energy consumption and changes in indoor temperatures

This figure illustrates the high energy demand when temperatures range between 30 and 32 °C. Energy demand for Saturday, May 3, is not recorded due to a power outage during the selected time period. Thus, high temperatures were observed on May 1 and 4, but energy demand was very low. This is explained by the fact that May 1 was a non-working day and May 4 was a Sunday, a day when building occupancy is low.

3.6. Simulation in Edge Building

The Edge Building software is a simple, fast, and reliable tool that allows you to assess the energy and environmental performance of an existing building while identifying the most effective measures for optimizing its efficiency. After calculation, the software indicated that the building's energy consumption is 299,267 kWh/year. The second step selecting energy efficiency measures that achieve savings of at least 20 %, in accordance with the EDGE energy performance standard is based on three main components: energy, water, and materials. Given that water is rarely used in the building and that the building is already existing, the various improvement scenarios were developed based solely on the energy component.

Energy Efficiency Measures

Window-to-wall ratio

The figure 12 shows the Energy efficiency measures for windows and walls (Source: Edge Building).

Figure 12. Energy efficiency measures for windows and walls (Source: Edge Building)

The building's glazing ratio is 18 %. Since the building is located in a tropical country, the glazing ratio should not be high, as sunlight passes through the windows very quickly. Therefore, to reduce the thermal load in the building, the WWF value was adjusted to 15 %. This measure achieves a 2.64 % improvement, enhances occupant comfort in non-air-conditioned spaces, and reduces the air-conditioning load in air-conditioned spaces.

Reflective roof

The figure 13 illustrates the Energy Efficiency Measures: Reflective Roof (Source: Edge Building).

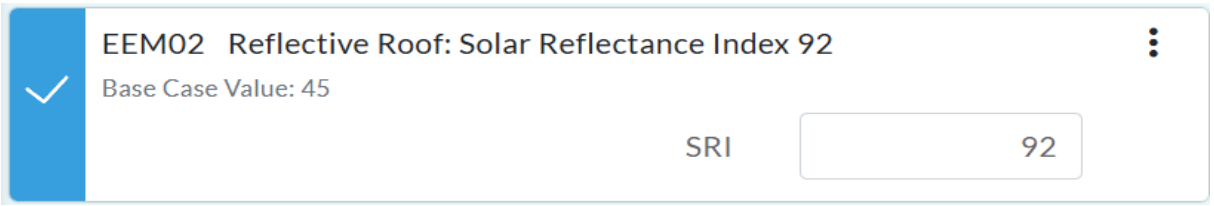


Figure 13. Energy Efficiency Measures : Reflective Roof (Source : Edge Building)

The building's roof is dark in color, which contributes to heat gain ; therefore, to reduce its thermal load, an IRS of 92 is proposed, corresponding to that of a white metal roof. In practice, the existing roof would need to be replaced with another white metal roof. This measure achieves 6.57 % energy savings, improves occupant comfort in non-air-conditioned spaces, and reduces the air conditioning load in air-conditioned spaces.

Reflective exterior walls

The figure 14 illustrates the Energy Efficiency Measures: Reflective Exterior Walls (Source: Edge Building).

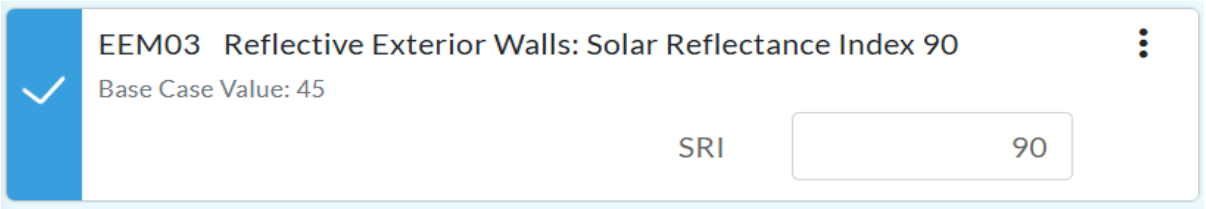


Figure 14. Energy Efficiency Measures : Reflective Exterior Walls (Source : Edge Building)

of the facades of the audited building are painted a dark color with a high absorption coefficient. Therefore, to reduce heat gain in the building, an IRS of 90 was proposed. This corresponds to the IRS of a white-painted concrete wall. This measure achieves 0.42 % energy savings, improves occupant comfort in non-air-conditioned spaces, and reduces the air conditioning load in air-conditioned spaces.

Glazing efficiency

The figure 15 shows the Energy Efficiency Measures: Window Efficiency (Source: Edge Building)

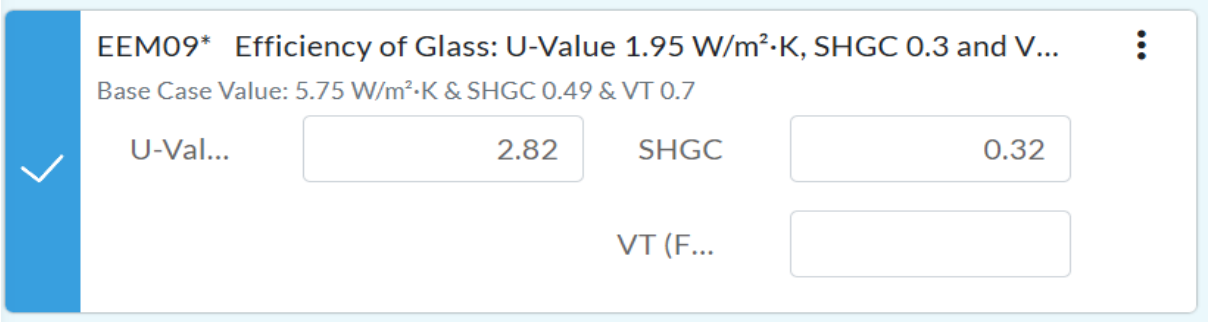


Figure 15. Energy Efficiency Measures : Window Efficiency (Source : Edge Building)

Glazing coatings can reduce or increase heat transfer from one side of the glazing to the other. To improve the efficiency and durability of the coating, an 8 mm gray (pyrolytic) coating is recommended, with a solar heat gain coefficient (SHGC) of 0.32 and a U-value of 2.82. This measure achieves 0.36 % energy savings, improves occupant comfort in non-air-conditioned spaces, and reduces the air-conditioning load in air-conditioned spaces.

Air infiltration through the building envelope

Figure 16 shows the Energy Efficiency Measures – Building Envelope Air Infiltration (Source: Edge Building).

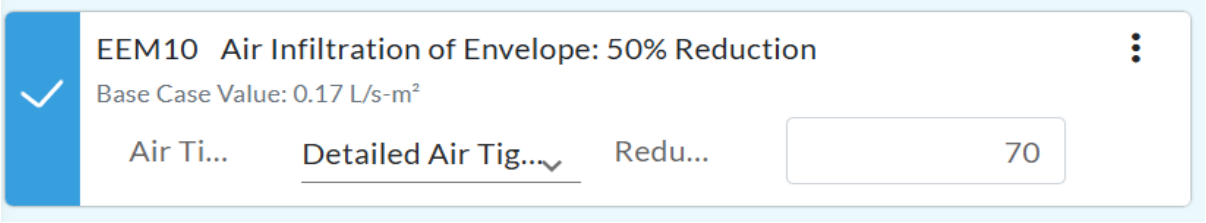


Figure 16. Energy Efficiency Measures – Building Envelope Air Infiltration (Source : Edge Building)

During the inspection, it was found that some broken windows allow hot air to infiltrate. As a result, air infiltration should be reduced by 70 %. This would result in energy savings of 0.75 %, improve occupant comfort in non-air-conditioned spaces, and reduce the air conditioning load in air-conditioned spaces.

Air Conditioning System Efficiency

The figure 17 illustrates the Energy Efficiency Measures – Cooling System Efficiency (Source: Edge Building).

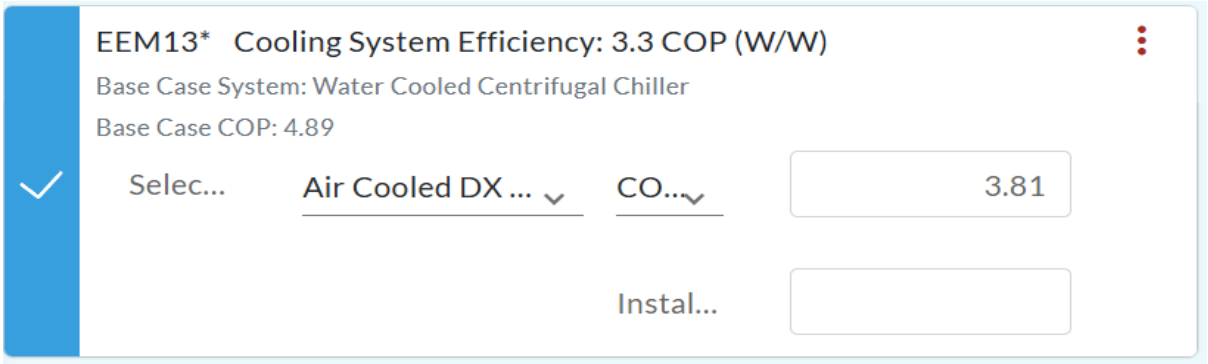


Figure 17. Energy Efficiency Measures – Cooling System Efficiency (Source : Edge Building)

The building's largest energy load comes from air conditioning. While other measures will significantly reduce the air conditioning load, it is also important to install an efficient cooling system with a high COP. Thus, air-cooled air conditioners with a COP of 3.81 are recommended, and proper sizing of the cooling capacity relative to room volume is ideal. These measures will result in 1.98 % energy savings.

High-efficiency, low-consumption lighting

The Energy Efficiency Measures: High-Efficiency Lighting for Outdoor and Indoor Spaces (Source: Edge Building, 2020) is presented in figure 18.

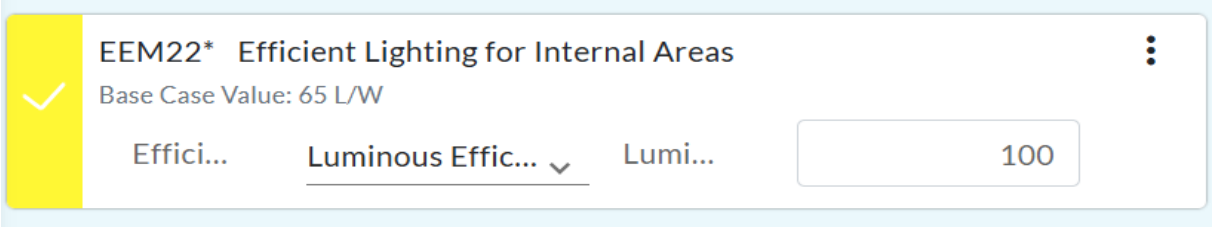


Figure 18. Energy Efficiency Measures : High-Efficiency Lighting for Outdoor and Indoor Spaces (Source : Edge Building)

The lamps used in the building are fluorescent lamps with ballasts. They consume a significant amount of energy and also increase residual heat. Consequently, LED lamps with an efficiency of 100 lm/W are proposed for both the exterior and interior of the building. This will result in 6.93 % energy savings, improve occupant comfort in non-air-conditioned spaces, and reduce the load on the air conditioning system in air-conditioned spaces.

Lighting control

The figure 19 illustrates the Energy Efficiency Measures: Lighting Control (Source: Edge Building).

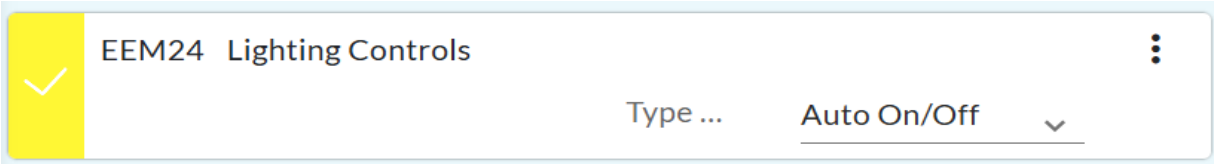


Figure 19. Energy Efficiency Measures : Lighting Control (Source : Edge Building)

Since lighting is the second-largest source of energy consumption, it is recommended to use it efficiently and only when necessary. An automatic on/off lighting control system will turn a room's lights on or off only if human presence is detected. This measure can achieve energy savings of 1.49 %.

Raising awareness among occupants (users)

We need to raise awareness among building occupants about energy conservation, as they are the primary agents of change. Strategies such as communication via newsletters, posters, training sessions on eco-friendly practices, and suggestion boxes to encourage them to share ideas can be implemented. These initiatives will help engage occupants in sustainable energy management and promote eco-friendly behaviors. This measure will result in energy savings of 2 %.

Thus, implementing all these measures will result in energy savings of 23.14 % on the building's total energy consumption and will improve the comfort and environmental performance of the building envelope. Among the identified efficiency measures, two are estimated to have an affordable investment cost and a short payback period: high-efficiency, low-energy lighting and occupant awareness initiatives.

High-efficiency, low-energy lighting

High-efficiency lamps, which produce more light using less energy than traditional incandescent bulbs, reduce a building's energy consumption for lighting. They reduce residual heat in the premises, which in turn reduces cooling requirements. Maintenance costs are also lower, as the lifespan of LED lamps is longer (15,000–50,000 hours) than that of fluorescent lamps (6,000–20,000 hours). As a result, all fluorescent lamps are to be replaced with LED lamps, and the power consumption involved is 16 kW, which will be reduced by at least 50 %.

Raising Awareness Among Building Users

Raising awareness among building users (teachers, administrative staff, and students) about energy conservation through a number of strategies will help engage them in sustainable energy management and encourage eco-friendly behaviors. The energy savings resulting from this measure have been estimated at 2 %.
Accordingly, a project sheet outlining the energy and financial savings achieved after implementing these two measures has been developed.

Table 8. Project Overview: High-Efficiency, Low-Energy Lighting

Description	Value	Unit	Comments
BASIC DATA			
Energy cost			
energy consumption	364 386	kWh	
Amount	107 278 882	CDF Excluding tax	
	294,41	CDF /kWh	
Building floor area (all levels)	15 561,37	Sq.m.	
Energy requirements	22,4346571	kWh/sq.m.	
EXPECTED GAINS			
Power	16	kW	
Rated power	8	kW	
operating hours	2 920	h	
Electricity	14 %	of total consumption	
Energy savings	23 360	kWh/year	
Cost savings	6 877 417	CDF	
INVESTMENT			
Number of lamps	322		
Unit cost	27480	CDF	
TOTAL INVESTMENT	8 848 560	CDF	
GROSS PAYBACK PERIOD	1,28661095~ 1 year and 4 months	YEAR	

With a total investment of 8,848,560 CDF, the annual savings generated by replacing the existing lighting with high-efficiency, low-energy lighting are estimated at 23,360 kWh/year and 6,877,417 CDF. The gross payback period is 1 year and 4 months, confirming the high profitability and economic viability of this measure. Thus, the high-efficiency, low-energy-consumption lighting measure is: highly profitable, low-risk, and easy to implement. It falls into the category of low investment and high return.

Table 9. Occupant Awareness

Description	Value	Unit	Comments
BASIC DATA			
Energy cost			
energy consumption	364 386	kWh	
Amount	107 278 882	CDF Excluding tax	
	294,41	CDF /kWh	
Building floor area (all levels)	15 561,37	Sq.m.	
Energy Requirements	22,0823855	kWh/Sq.m./year	
EXPECTED GAINS			
Power	2 %	of total consumption	
Rated power	7 287,72	kWh/year	
operating hours	2 145 577	CDF	
INVESTMENT			
Basic investment	1 000 000	CDF	
TOTAL INVESTMENT	1 000 000	CDF	
GROSS PAYBACK PERIOD	0,46607506~ 5 months		

With a total investment of 1,000,000 CDF, the annual savings generated by raising occupants' awareness are estimated at 7,287 kWh/year and 2,145,577 CDF. The gross payback period is 5 months, confirming the high profitability and economic viability of this measure. Thus, the measure is: highly profitable, low-risk, and easy to implement. It falls into the category of: low investment and high return.

4. CONCLUSION

In summary, the energy audit conducted to assess the energy and environnemental performance of the Faculty of Science and Technology building at the University of Kinshasa in the DRC identified areas of energy consumption and determined the building's solar heat gain. This led to the proposal of energy efficiency measures capable of reducing

the building's energy consumption by 23 %. Subsequently, measures offering high returns with low investment were selected, including the replacement of existing light bulbs with high-efficiency, low-energy bulbs, as well as raising awareness among occupants. By implementing these measures, it is possible to achieve total energy savings of 30,647 kWh per year, which corresponds to financial savings of 9,022,994 CDF per year.

The total investment required for these improvements is 9,848,560 CDF, with an average gross payback period of 1 year and 9 months. Overall, these initiatives will reduce energy consumption by 8 % and improve occupant comfort, thereby contributing to greater energy efficiency and substantial savings.

Looking ahead to future research in this field, which remains largely unexplored in the DRC, studies should be conducted on the energy and environmental performance of residential buildings, and a comparative study should be carried out between residential buildings constructed in rural and urban areas, develop more accurate simulation software tailored to the local context in order to present evidence to decision-makers so that, together, we can rethink the design of buildings in the DRC, which should be constructed with materials suited to the local climate and resilient to the effects of climate change.

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