Energy Consumption Analysis and Energy Efficiency Improvement of Lighting and Air-conditioning Systems of a Private Hospital in Laguna

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Abstract
This study aimed to analyze energy consumption patterns and improve the energy efficiency of lighting and air-conditioning systems in a private tertiary hospital in Laguna. It focused on identifying inefficiencies, evaluating system performance against established benchmarks, and proposing appropriate energy conservation measures. A descriptive-developmental research design was employed using a preliminary (Level 1) energy audit. Data were collected from historical electricity records, equipment inventory, and on-site inspections. Benchmarking standards included the Government Energy Management Program (GEMP), Republic Act No. 11285, and ISO 50002. Analytical procedures involved energy consumption analysis, efficiency evaluation using equipment performance indicators, and identification of energy wastage in both technical and financial terms.

Findings showed that air-conditioning systems are the primary contributors to energy consumption, with inefficiencies largely due to outdated equipment, improper operational practices, and limited monitoring. The study concludes that implementing targeted energy conservation measures—such as system optimization, lighting upgrades, and improved operational controls—can significantly reduce energy use and operational costs. A comprehensive Energy Management Plan (EMP) was developed to support sustainable practices and ensure compliance with national standards.

Keywords: Energy Efficiency, RA No. 11285, Lighting and Air-Conditioning Systems, Compliance Assessment, Energy Management Plan

1. Introduction

Energy consumption in hospitals has emerged as a critical concern in global sustainability efforts due to the inherently high energy demands of healthcare operations. Unlike conventional commercial buildings, hospitals operate continuously, requiring the uninterrupted delivery of medical services while maintaining strict environmental conditions for patient safety, staff efficiency, and equipment reliability. This continuous operation results in extensive use of lighting systems, heating, ventilation, and air-conditioning (HVAC), as well as specialized medical equipment, leading to substantial electrical consumption [1]. Consequently, improving energy efficiency in hospitals is not only essential for reducing operational costs but also for enhancing resilience, service quality, and environmental sustainability.

Recent global health challenges, particularly the COVID-19 pandemic, have further underscored the importance of effective ventilation and air-conditioning systems in healthcare facilities. Adequate ventilation plays a vital role in mitigating airborne disease transmission, especially in high-risk environments such as intensive care units and isolation wards. The World Health Organization [2] emphasizes the necessity of proper ventilation, while Leung *et al.* [3] demonstrated that poor ventilation significantly contributes to the spread of infectious agents. These findings highlight that maintaining safe indoor air conditions often increases energy demand, thereby necessitating a balance between infection control and energy efficiency.

At the national level, the Philippine government has strengthened its commitment to energy efficiency through the enactment of Republic Act No. 11285, or the Energy Efficiency and Conservation Act, which mandates institutions, including hospitals, to adopt energy-efficient practices and conduct regular energy audits. The Department of Energy [4] further provides guidelines for energy-efficient building design, particularly in lighting systems, insulation, and air-conditioning performance. Despite these regulatory frameworks, many healthcare facilities continue to encounter challenges in implementation due to limited technical capacity, insufficient baseline energy data, and the absence of structured monitoring systems.

More critically, there remains a significant lack of empirical, facility-level energy audit data in private hospitals, particularly in quantifying energy consumption patterns, identifying inefficiencies, and assessing compliance with national and international benchmarks. Although technological advancements such as artificial intelligence (AI) and Internet of Things (IoT)-based systems have demonstrated substantial potential in improving energy efficiency [5], [6], their adoption in Philippine healthcare settings remains limited. Similarly, intelligent lighting technologies have shown measurable reductions in electricity consumption [7], [8], yet financial constraints, technical complexity, and lack of specialized expertise hinder widespread implementation. Local studies further reveal persistent issues such as outdated infrastructure and inadequately trained personnel [9], [10].

In response to these gaps, this study conducts a quantitative preliminary energy audit of a private tertiary hospital in Laguna, specifically the University of Perpetual Help – Dr. Jose G. Tamayo Medical University Hospital (UPH–JGT-MUH). The study focuses on analyzing energy consumption patterns of lighting and air-conditioning systems, evaluating equipment performance relative to established standards like the Government Energy Management Program (GEMP), quantifying energy inefficiencies and wastage, and assessing compliance with Republic Act No. 11285. Based on the findings, it proposes cost-effective Energy Conservation Measures (ECMs) and develops a comprehensive Energy Management Plan (EMP). By integrating energy analysis, benchmarking, and strategic planning, this study contributes to the development of data-driven energy management strategies and provides a replicable framework for enhancing energy efficiency in Philippine healthcare facilities while aligning with national policies and global sustainability goals.

2. Method

A descriptive developmental research design. The descriptive component was used to analyze existing energy consumption patterns, identify inefficiencies, and evaluate the performance of major energy-consuming systems without manipulating variables. This approach is appropriate for energy audit studies as it provides an accurate representation of actual operating conditions [5], [6].

Specifically, the study adopted a preliminary (Level 1) energy audit, which involves data collection, visual inspection, and basic engineering analysis. According to the Department of Energy [4], this method is effective in identifying major energy users, estimating energy wastage, and recommending cost-effective energy conservation measures. The developmental component was reflected in the formulation of an Energy Management Plan (EMP), developed based on audit results and benchmarking analysis. This aligns with recent studies emphasizing that data-driven energy management frameworks improve efficiency and support sustainable operations [6].

Primary data were collected from the hospital's facilities and operational records. These included historical electricity consumption data for the most recent 12-month period, with consideration of earlier records corresponding to the Government Energy Management Program (GEMP) base year (2015), where available. Additional data comprised equipment inventories of lighting and air-conditioning systems, as well as operational schedules.

To support the analysis, the researcher conducted on-site inspections (walk-through audit) of lighting systems and air-conditioning units to assess their operating conditions and identify potential inefficiencies. Informal consultations with facility managers and maintenance personnel were also undertaken to validate operational practices, equipment usage patterns, and possible sources of energy wastage.

Basic energy audit instruments, including lux meters, laser distance meters, and temperature and humidity data loggers, were used to assess lighting, environmental conditions, and space requirements for energy estimation. Structured checklists and data templates documented equipment, schedules, and load patterns, while charts and diagrams identified inefficiencies. A cost-benefit framework evaluated the savings and feasibility of proposed ECMs. Data reliability and validity were ensured through calibration, repeated measurements, pilot testing, and triangulation with sources such as manufacturer data, historical records, and standards from the Department of Energy, supported by personnel consultations and Level 1 audit guidelines.

The proposed EMP was validated by experts to ensure feasibility and alignment with energy management principles and Republic Act No. 11285. Expert validation, supported by Gibbs [11], guided revisions to improve clarity and applicability. Data triangulation further strengthened validity by cross-checking multiple sources, consistent with Creswell & Creswell [12]. Overall, the instruments and EMP were confirmed to be reliable, comprehensive, and suitable for evaluating energy efficiency and compliance.

A 5-point Likert scale was utilized to assess each criterion of the proposed Comprehensive Energy Management Plan (CEMP), where 5 represents the highest level of agreement, and 1 represents the lowest. This method is widely recognized as appropriate for evaluating program effectiveness and acceptability, as it enables experts to systematically rate different aspects of a proposed plan [13], [14].

Table 1: Five-Point Likert Scale

Assigned Points	Ordinal Rating Scale	Numerical Range	Verbal Interpretation
5	Highly Valid / Excellent	4.21-5.00	Highly Acceptable
4	Valid / Good	3.41-4.20	Acceptable
3	Moderately Valid / Acceptable	2.61-3.40	Moderately Acceptable
2	Fair / Needs Major Revision	1.81-2.60	Slightly Acceptable
1	Invalid / Poor	1.00-1.80	Not Acceptable

The study followed a structured Level 1 (walk-through) energy audit process, beginning with securing approval to access hospital records and conduct inspections, followed by collecting electricity data, equipment inventory, and operational schedules. A site inspection was then performed to observe system conditions, document usage, and measure key parameters, with data validated through cross-checking and consultations with facility personnel. Finally, all information was consolidated and analyzed to assess energy use, identify inefficiencies, and develop appropriate Energy Conservation Measures (ECMs) and an Energy Management Plan (EMP)

Percentage distribution was used to determine the share of total energy consumption attributed to lighting and air-conditioning systems, helping identify major energy users and prioritize efficiency improvements. The weighted mean was applied to evaluate the validity and acceptability of the proposed Comprehensive Energy Management Plan (CEMP) based on expert ratings, ensuring its practicality and alignment with industry and regulatory standards.

A one-sample t-test was used to determine whether the mean energy consumption significantly differed from the Government Energy Management Program (GEMP) benchmark at a 0.05 level of significance, providing statistical evidence for hypothesis testing. Overall, these methods ensured a systematic, objective analysis and supported data-driven conclusions aligned with Republic Act No. 11285.

3. Results and Discussion

Findings are organized based on the Statement of the Problem and examine energy use patterns, system performance, inefficiencies, and compliance with established standards, serving as the basis for proposed Energy Conservation Measures (ECMs) and the development of an Energy Management Plan (EMP).

Table 2: Estimated Significant Energy Use (SEU) of the Hospital in Terms of Lighting and Air-Conditioning Systems

Year	Total Consumption (kWh)	Air-Conditioning (kWh)	Lighting (kWh)	SEU Rank	SEU Status
2015	2,274,058.32	1,250,732.08	568,514.58	AC > Lighting	Dominant SEU
2016	2,442,828.84	1,343,555.86	610,707.21	AC > Lighting	Dominant SEU
2017	2,472,037.33	1,359,620.53	618,009.33	AC > Lighting	Dominant SEU
2018	2,585,268.24	1,421,897.53	646,317.06	AC > Lighting	Dominant SEU
2019	2,534,538.61	1,393,996.24	633,634.65	AC > Lighting	Dominant SEU
2020	2,363,245.51	1,299,785.03	590,811.38	AC > Lighting	Dominant SEU
2021	2,912,417.83	1,601,829.81	728,104.46	AC > Lighting	Dominant SEU
2022	3,054,959.73	1,680,227.85	763,739.93	AC > Lighting	Dominant SEU
2023	2,973,493.19	1,635,421.25	743,373.30	AC > Lighting	Dominant SEU
2024	3,229,226.32	1,776,074.48	807,306.58	AC > Lighting	Dominant SEU
2025	3,144,296.32	1,729,362.98	786,074.08	AC > Lighting	Dominant SEU

Table 2 presents that air conditioning consistently dominates the hospital's energy consumption from 2015 to 2025, accounting for about 55% of total electricity use, while lighting contributes around 25%, aligning with international benchmarks [15-17]. Annual air-conditioning consumption ranges from approximately 1.25 to 1.78 million kWh, more than double that of lighting, with both systems showing an increasing trend, particularly from 2021 to 2024. This pattern reflects the continuous operation of HVAC systems in hospitals to maintain controlled environments [18], reinforcing air conditioning as the primary Significant Energy Use (SEU). The stable dominance of cooling systems indicates that inefficiencies in AC significantly impact overall consumption, highlighting the need to prioritize HVAC efficiency improvements, operational control, and scheduling in energy management strategies, while lighting measures remain secondary.

Table 3: Major Sources of Energy Inefficiency and Estimated Energy Wastage of Air Conditioning Units

Capacity	Key Source of Energy Inefficiency	Ave. Actual CSPF	Operating Pattern	Share of Total (%)	Estimated Daily Energy Wastage (kWh/day)	Estimated Annual Energy Wastage (kWh/year)
1.0 HP	Low CSPF (2.75–3.1 vs 3.7); several 24-hr units	~2.95	Mixed (9–24 hrs, several 24-hr units)	3.50%	71.66	26,156.00
1.5 HP	CSPF below standard; multiple units with extended use	~2.91	Mostly 10–24 hrs	9.60%	197.76	72,181.00
2.0 HP	CSPF below standard; multiple units with extended use	~2.94	9–24 hrs (many 24-hr critical loads)	45.60%	939.70	343,490.50
2.5 HP	Moderate CSPF gap; clustered 24-hr operation (notably 7 units)	~2.93	9–24 hrs	7.70%	159.36	58,166.40
3.0 HP	Continuous operation with suboptimal efficiency	~2.95	24 hrs	0.70%	13.85	5,055.30
3 TR	Large-capacity units with low CSPF (2.8–2.9); long operating hours	~2.86	10–24 hrs	18.50%	381.43	139,222.00
5 TR	High cooling loads + efficiency gap; extended use	~2.83	10–24 hrs	14.20%	293.00	106,945.00
Total Energy Wastage	-	-	-	-	2,058.71 kWh/day	751,430.45 kWh/year

Table 3 indicates that the hospital's air-conditioning units generate significant energy wastage of 2,058.71 kWh/day (751,430.45 kWh/year), with 2.0 HP units contributing the largest share (45.60%) due to high quantity, long operating hours, and low CSPF values, while larger systems like 3 TR and 5 TR units also contribute substantially despite fewer units because of high cooling loads and extended use. The findings confirm that inefficiency is driven by both equipment performance and operational practices, consistent with the International Energy Agency [19] and the Department of Energy [20], highlighting low efficiency ratings, prolonged operation, and system clustering as key factors. These results suggest prioritizing high-impact units for replacement with efficient inverter systems and improving operational strategies, such as scheduling and load management, supporting the need for an integrated Energy Management Plan aligned with Republic Act No. 11285 and the Government Energy Management Program to reduce energy use, lower costs, and enhance sustainability.

Table 4: Performance of Lighting System Relative to International Energy Efficiency Standards (LPD-Based)

Building	Floor	Actual LPD (W/m²)	Standard LPD (W/m²)	Gap (W/m²)	% Below Standard	Interpretation
Hospital Building	GF	2.14	8–15	−5.86 to −12.86	73%–86% lower	Very Low LPD
	2F	2.44	8–15	−5.56 to −12.56	70%–84% lower	Very Low LPD
	3F	1.86	8–15	−6.14 to −13.14	77%–88% lower	Extremely Low
	4F	1.65	8–15	−6.35 to −13.35	79%–89% lower	Extremely Low
Tamayo Tower	Basement	1.40	8–15	−6.60 to −10.60	82%–88% lower	Extremely Low
	GF	3.06	8–15	−6.94 to −11.94	69%–80% lower	Very Low
	2F	4.76	8–15	−5.24 to −10.24	52%–68% lower	Low
	3F	3.24	8–15	−2.76 to −6.76	46%–68% lower	Low
	4F	2.73	8–15	−3.27 to −7.27	55%–73% lower	Very Low
	5F	1.94	8–15	−4.06 to −8.06	68%–81% lower	Extremely Low
	6F	1.92	8–15	−4.08 to −8.08	68%–81% lower	Extremely Low
	7F	4.03	8–15	−1.97 to −5.97	33%–60% lower	Low

Table 4 shows that the hospital's Lighting Power Density (LPD) ranges from 1.40 to 4.76 W/m², significantly below the 8–15 W/m² standard, indicating high energy efficiency but also suggesting potential underlighting that may affect safety and functionality. While low LPD reflects minimal energy use, standards from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers [21] and the Illuminating Engineering Society [22] emphasize that lighting must still meet required illumination levels, especially in healthcare settings. These findings imply that the hospital should focus on optimizing lighting design—such as improving layout or upgrading to efficient LED systems—rather than further reducing energy use, ensuring a balance between efficiency and adequate illumination while supporting compliance with Republic Act No. 11285.

On the other hand, Table 4.2 shows a clear performance gap between inverter and non-inverter air-conditioning units, with inverter systems (about 30%) achieving CSPF values of 4.3–4.6 and meeting both ASEAN and DOE standards, while non-inverter units (around 70%) fall below required levels (2.8–3.1) and are classified as inefficient and non-compliant. As a result, the overall system performance is poor, since the dominance of low-efficiency units outweighs the benefits of high-performing ones, highlighting that system efficiency depends on the overall composition rather than isolated equipment performance, consistent with standards from the International Energy Agency [16] and the ASEAN Centre for Energy [17].

These findings suggest that improving system efficiency requires prioritizing the replacement of non-inverter units with inverter technologies, as well as adopting a system-wide approach through phased upgrades, standardization, and policy alignment. Such actions support compliance with Republic Act No. 11285, reduce energy consumption and costs, and reinforce the need for a comprehensive Energy Management Plan (EMP) that integrates both technical and strategic interventions.

Table 5: Performance of Air-Conditioning System Relative to International Energy Efficiency Standards (CSPF-Based)

Category	Estimated Share (%)	Average CSPF	ASEAN Minimum (3.7)	DOE Standard (3.32)	Gap vs ASEAN	Performance Status	Compliance
Inverter Units	~30%	4.3 – 4.6	3.7	3.32	+0.3 to +1.1	Efficient to Highly Efficient	Compliant
Non-Inverter Units	~70%	2.8 – 3.1	3.7	3.32	−0.6 to −0.9	Inefficient	Not Compliant
Overall System	100%	—	3.7	3.32	Below standard	Poor	Mostly Non-compliant

Table 5 outlines targeted Energy Conservation Measures (ECMs) that prioritize air-conditioning improvements due to its dominant energy use, with replacing non-inverter units offering the highest savings (20%–40%) but requiring significant investment, while low-cost actions like scheduling and preventive maintenance provide immediate and practical savings (5%–25%). Additional strategies such as load zoning, energy monitoring, LED retrofits, and smart controls aim to optimize system performance, address underlighting, and balance energy efficiency with operational needs, consistent with recommendations from the International Energy Agency [16] and the Department of Energy [20]. The findings suggest a phased approach, starting with low-cost, high-impact measures to achieve quick savings, followed by long-term investments in efficient technologies like inverter ACUs to address core inefficiencies. Emphasizing continuous monitoring, strategic planning, and behavioral change, the implementation of these ECMs through a comprehensive Energy Management Plan (EMP) supports compliance with Republic Act No. 11285 while reducing costs and improving sustainability.

Table 5: Proposed Energy Conservation Measures (ECMs) for Improving Energy Efficiency

Energy Conservation Measure (ECM)	Description	Target System	Expected Impact	Cost Level	Priority Level
Replacement with Inverter ACUs	Replace non-inverter units (CSPF 2.8–3.1) with inverter units (CSPF ≥ 4.0)	Air-Conditioning	20%–40% energy savings	High	High
ACU Operational Scheduling	Reduce 24-hour operation; implement timer/controls	Air-Conditioning	10%–25% reduction in wastage	Low	High
Preventive Maintenance Program	Regular cleaning, refrigerant check, and servicing	Air-Conditioning	5%–15% efficiency improvement	Low	High
Load Optimization / Zoning	Match ACU capacity with actual cooling demand	Air-Conditioning	10%–20% savings	Medium	High
Lighting System Optimization	Increase lighting levels to meet lux standards using efficient LEDs	Lighting	Improved compliance with minimal energy increase	Medium	Medium
Smart Lighting Controls	Install occupancy sensors and daylight sensors	Lighting	10%–30% energy savings	Medium	Medium
LED Retrofit (if needed)	Replace remaining inefficient fixtures	Lighting	10%–20% savings	Medium	Medium
Energy Monitoring System	Install sub-metering and real-time monitoring	Both Systems	5%–10% overall efficiency improvement	Medium	High
Energy Awareness Program	Train staff on energy-saving practices	Both Systems	3%–8% behavioral savings	Low	Medium

Table 6 shows that the hospital's energy consumption from 2015 to 2025 is significantly higher than the Government Energy Management Program (GEMP) benchmark ($t = 6.589$, $p < .001$), leading to the rejection of the null hypothesis and confirming non-compliance with the target of approximately 2.05 million kWh. While earlier years were closer to the benchmark, energy use increased notably from 2022, peaking at about 3.23 million kWh in 2024, indicating that existing strategies were insufficient to manage rising demand. These findings suggest inefficiencies in both system performance and operational practices, particularly in high-load systems, and highlight the need for a comprehensive, data-driven Energy Management Plan with targeted interventions, improved monitoring, and alignment with Republic Act No. 11285 to achieve compliance and long-term sustainability.

Table 6: Difference Between Energy Performance and GEMP Target

Groups	Mean	SD	t^a	p^b	Interpretation
Energy performance (2015-2025)	2726033.66	*341967.17*	*6.589*	<.001	Significant
GEMP Target	2046652.49				

Table 7 outlines a comprehensive Energy Management Plan (EMP) that addresses key inefficiencies in air-conditioning and lighting through a combination of policy, technical, and operational strategies. Major interventions include establishing an energy policy, replacing non-inverter ACUs, implementing preventive maintenance, and applying control measures such as scheduling and zoning, alongside system optimization through lighting upgrades, smart controls, and energy monitoring. The plan also incorporates continuous activities like audits, reporting, and staff training to support data-driven decisions and promote energy-efficient behavior, consistent with frameworks from the International Organization for Standardization [23] and the Department of Energy [20].

The EMP adopts a holistic and phased approach, combining low-cost, high-impact measures for immediate savings with long-term investments such as equipment upgrades to ensure sustained improvement. This structured strategy enhances feasibility, strengthens compliance with the Government Energy Management Program, and supports Republic Act No. 11285, enabling the hospital to reduce costs, improve performance, and achieve long-term sustainability.

Table 7: Proposed Energy Management Plan (EMP) for Improving Energy Efficiency

Program Component	Action Plan	Target System	Timeline	Responsible Unit	Expected Outcome
Energy Policy Development	Establish institutional energy efficiency policy aligned with DOE and ASEAN standards	Both Systems	Short-term (0–6 months)	Administration / Engineering	Formalized commitment to energy efficiency
ACU Replacement Program	Gradual replacement of non-inverter units with inverter systems	Air-Conditioning	Medium to Long-term (1–5 years)	Engineering / Procurement	20%–40% reduction in cooling energy consumption
Preventive Maintenance Program	Schedule regular inspection, cleaning, and servicing of ACUs	Air-Conditioning	Continuous	Engineering / Maintenance	Sustained efficiency and extended equipment life
Operational Control Strategy	Implement scheduling, temperature control, and zoning	Air-Conditioning	Short-term (0–1 year)	Engineering / Facility Management	Reduced unnecessary energy consumption
Lighting Optimization Program	Adjust lighting design to meet lux standards using efficient fixtures	Lighting	Short-term (0–1 year)	Engineering	Improved lighting quality with efficient consumption
Smart Control Systems	Install occupancy sensors, timers, and energy monitoring systems	Both Systems	Medium-term (1–3 years)	Engineering / IT	Data-driven energy management and reduced wastage
Energy Monitoring and Reporting	Implement sub-metering and monthly energy performance review	Both Systems	Continuous	Energy Manager / Engineering	Improved tracking and decision-making
Capacity Building and Training	Conduct energy awareness seminars for staff	Both Systems	Continuous	HR / Energy Manager	Behavioral energy savings (3%–8%)
Energy Audit Program	Conduct periodic internal and external energy audits	Both Systems	Annual	Certified Energy Auditor	Continuous system improvement

4. Conclusions

Based on the findings of the study, the following conclusions were drawn:

- Air-conditioning systems are the primary drivers of energy consumption and represent the most critical area for energy efficiency improvement.
- Energy inefficiency results from both technical factors (low CSPF and outdated equipment) and operational practices (extended operating hours and poor scheduling).
- While the lighting system is energy-efficient, it may not meet required illumination standards, indicating a need for optimization rather than further reduction. Moreover, the air-conditioning system is highly inefficient, primarily due to the dominance of non-inverter units operating below ASEAN and DOE standards
- Phased energy management strategy, such as prioritizing low-cost operational improvements first, followed by capital-intensive upgrades like inverter ACUs, offers the most effective and sustainable approach to reducing energy consumption, is expected to improve efficiency and support compliance with Republic Act No. 11285.
- Based on the findings, there is a statistically significant difference between the hospital's energy performance and the benchmark set under the Government Energy Management Program (GEMP), with the hospital's energy consumption significantly exceeding the benchmark-aligned target value. This indicates deviation from national energy efficiency benchmarks and reflects deficiencies in current energy management practices, particularly in controlling high energy-consuming systems such as air-conditioning. The increasing trend in energy consumption further suggests that existing strategies are insufficient to sustain the required reductions over

time. Therefore, the hospital must adopt a more structured and data-driven approach to energy management, aligned with Republic Act No. 11285, to improve efficiency, reduce overall consumption, and achieve long-term compliance and sustainability.
- The study concludes that the proposed Energy Management Plan (EMP) provides a practical and comprehensive framework for improving the hospital's energy performance. By integrating policy development, technical upgrades, operational controls, and behavioral strategies, the EMP effectively addresses the root causes of energy inefficiency. Its phased and system-oriented approach ensures feasibility while supporting continuous improvement. The EMP serves as a strategic tool to enhance energy efficiency, reduce operational costs, and strengthen compliance with national and regional energy standards.

5. Recommendation

Based on the conclusions of the study, the following recommendations are proposed to further enhance energy management practices, ensure compliance with Republic Act No. 11285, and guide future research:

- The Hospital Administrator should prioritize improving the efficiency of air-conditioning systems through targeted Energy Conservation Measures (ECMs), such as upgrading to inverter-based units and optimizing cooling operations.
- To address both technical and operational inefficiencies, it is recommended to replace outdated equipment with higher-efficiency units and implement strict operational controls, including proper scheduling, zoning, and reduction of unnecessary operating hours.
- The hospital should optimize its lighting system by ensuring compliance with recommended illumination standards while maintaining energy efficiency through appropriate fixture selection and layout adjustments rather than reducing lighting levels.
- The Energy Management Team should strengthen energy management practices by adopting more aggressive energy reduction strategies and improving monitoring systems aligned with the Government Energy Management Program (GEMP).
- The Hospital Administrator and Energy Management Team should fully implement and institutionalize a comprehensive Energy Management Plan (EMP), including continuous monitoring, regular audits, and targeted ECMs, in accordance with Republic Act No. 11285.
- The hospital should adopt and sustain the proposed EMP by integrating policy development, technical improvements, operational controls, and staff engagement programs. A phased implementation strategy should be followed to ensure feasibility, continuous improvement, and long-term compliance with national and regional energy standards.
- Future Researchers are encouraged to incorporate Work Environmental Measurement (WEM) in their studies to establish more precise and standardized benchmarks for workplace conditions. In particular, the use of WEM in illumination assessment can provide objective and quantifiable data to support the development of evidence-based lighting standards, thereby improving the accuracy, reliability, and standardization of environmental evaluations in similar healthcare and institutional settings.

References

1. International Energy Agency. Energy efficiency in buildings and healthcare facilities [Internet]. Paris: IEA; 2023 [cited 2026 May 8]. Available from: https://www.iea.org/energy-system/energy-efficiency-and-demand/energy-efficiency
2. World Health Organization. Roadmap to improve and ensure good indoor ventilation in the context of COVID-19 [Internet]. Geneva: WHO; 2021 [cited 2026 May 8]. Available from: https://www.who.int/publications/i/item/9789240021280
3. Leung NHL, Chu DKW, Shiu EYC, Chan KH, McDevitt JJ, Hau BJP, *et al*. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nat Med. 2020;26(5):676-80. Available from: https://pubmed.ncbi.nlm.nih.gov/32371934/
4. Department of Energy Philippines. Government Energy Management Program (GEMP) guidelines [Internet]. Philippines: DOE; 2022 [cited 2026 May 8].
5. Cheng X, Yu L. Smart air-conditioning systems using artificial intelligence and IoT for energy efficiency [Internet]. 2021 [cited 2026 May 8]. Available from: https://as-proceeding.com/index.php/ijanser/article/view/2947
6. Kim J, Park S, Lee H. AI-based predictive control for HVAC systems in smart buildings [Internet]. 2023 [cited 2026 May 8]. Available from: https://www.researchgate.net/publication/389347437_Artificial_Intelligence-Powered_HVAC_Systems_for_Enhancing_Comfort_and_Energy_Efficiency_in_Smart_Buildings
7. Ma Z, Cooper P, Daly D, Ledo L. Intelligent lighting systems and energy savings in buildings [Internet]. 2020 [cited 2026 May 8]. Available from: http://researchgate.net/publication/325286877_Intelligent_Lighting_Control_System_for_Energy_Savings_in_Office_Building
8. Mardiana-Idayu A, Riffat SB. Review on building energy consumption and lighting systems [Internet]. 2021 [cited 2026 May 8]. Available from: https://www.researchgate.net/publication/396974902_Energy_consumption_patterns_and_efficiency_strategies_in_the_built_environment_A_comprehensive_review
9. Macalintal R, Santos J, Cruz P. Barriers to energy efficiency implementation in Philippine hospitals [Internet]. 2022 [cited 2026 May 8]. Available from: https://commons.clarku.edu/cgi/viewcontent.cgi?article=1082&context=idce_masters_papers
10. Dela Cruz RZ, Ortega-Dela Cruz RA. Addressing facility management issues and challenges common among public health care institutions in a developing country. Int J Healthc Manag. 2021;14(3):748-54.
11. Gibbs GR. Analyzing qualitative data. 2nd ed. London: SAGE Publications; 2018.
12. Creswell JW, Creswell JD. Research design:

Qualitative, quantitative, and mixed methods approaches. 5th ed. Thousand Oaks (CA): SAGE Publications; 2018.
13. Likert R. A technique for the measurement of attitudes. Arch Psychol. 1932;22(140):1-55.
14. Boone HN Jr, Boone DA. Analyzing Likert data. J Ext. 2012;50(2):2TOT2. Available from: https://tigerprints.clemson.edu/joe/vol50/iss2/2
15. U.S. Department of Energy. Energy management best practices: Identifying energy savings opportunities [Internet]. Washington (DC): U.S. DOE; 2020 [cited 2026 May 8]. Available from: https://www.energy.gov/
16. International Energy Agency. Energy efficiency 2019 [Internet]. Paris: IEA; 2019 [cited 2026 May [8]]. Available from: https://www.iea.org/reports/energy-efficiency-2019
17. ASEAN Centre for Energy. Energy consumption in buildings report [Internet]. Jakarta: ASEAN Centre for Energy; 2020 [cited 2026 May 8]. Available from: https://asean.org/wp-content/uploads/2023/04/6th-asean-energy-outlook-2017-2040.pdf
18. World Health Organization. Natural ventilation for infection control in healthcare settings [Internet]. Geneva: WHO; 2009 [cited 2026 May 8]. Available from: https://www.who.int/publications/i/item/9789241547857
19. International Energy Agency. The future of cooling: Opportunities for energy-efficient air conditioning [Internet]. Paris: IEA; 2018 [cited 2026 May 8]. Available from: https://www.iea.org/reports/the-future-of-cooling
20. Department of Energy Philippines. Energy efficiency guidelines [Internet]. Philippines: DOE; 2020 [cited 2026 May 8]. Available from: https://prod-cms.doe.gov.ph/documents/d/eumb/building-guidelines-user-manual_final-pass-pdf
21. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Energy standard for buildings except low-rise residential buildings (ASHRAE Standard 90.1) [Internet]. Atlanta (GA): ASHRAE; 2019 [cited 2026 May 8]. Available from: https://www.ashrae.org/technical-resources/bookstore/standard-90-1
22. Illuminating Engineering Society. Lighting handbook [Internet]. New York: IES; 2020 [cited 2026 May 8]. Available from: https://www.researchgate.net/publication/360978266_The_IES_Lighting_Handbook_10th_Edition
23. International Organization for Standardization. ISO 50001: Energy management systems—Requirements with guidance for use [Internet]. Geneva: ISO; 2018 [cited 2026 May 8]. Available from: https://www.iso.org/standard/69426.html

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