GLOBAL INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

https://global-us.mellbaou.com/

Open Access

Cite this article Nasrullah, Awaluddin Hamdi. (2024). Planning, Operation And Supervision Of Energy Renewal Through Cooling Load And Thermal Comfort Of Hotel Buildings. Global International Journal of Innovative Research, 2(9). https://doi.org/10.59613/global.v2i9.289

Received: June, 2024
Accepted: July, 2024

Keywords:
Energy Planning, Energy Operation, Hotel Buildings

Author for correspondence:
Nasrullah
E-mail: nasrullah.nasrullah@universitasbosowa.ac.id

Planning, Operation and Supervision of Energy Renewal through Cooling Load and Thermal Comfort of Hotel Buildings

[1]Nasrullah, [2]Awaluddin Hamdi

Department of Architecture, Faculty of Engineering, Bosowa University Makassar City, Indonesia

Abstract. The research uses a quantitative approach with descriptive, inferential and SEM statistical analysis using the Partial Least Square (PLS) method. The results of the study found that energy management starting from planning, operation and supervision showed a target cooling load of 25°C and a humandity of 60% for hotel buildings. The results of the calculation of external and internal cooling loads indicate that the hotel building has implemented an energy strategy using low wattage air conditioners and inverters. The results of SEM-PLS analysis obtained that the variables of planning, operation and supervision directly have a significant influence on cooling load, thermal comfort and energy renewability. Cooling loads and thermal comfort directly have a significant effect on energy renewability. For the analysis of the overall specific indirect effect, the planning, operation and supervision variables have a significant effect on energy renewability through cooling load and thermal comfort. This means that energy renewability is determined by the implementation of energy management starting from planning, operation and supervision as well as the calculation of cooling loads and thermal comfort.

Published by:

GLOBAL SOCIETY PUBLISHING

1. Introduction

The global community is grappling with an energy crisis and air pollution, leading to increased demand for renewable energy to reduce reliance on conventional energy sources. Several developed countries, including Germany, Denmark, the United States, and China, have committed to using 100% renewable energy by mid-century. Renewable energy is crucial for meeting the demands of cooling, heating, electricity, and reducing fossil fuel consumption. The concept of Zero Energy Buildings (ZEB) has been applied globally, where buildings are classified as ZEBs when their energy consumption equals the amount of renewable energy produced.

Hotel buildings are among the highest energy consumers, with significant energy use tied to air conditioning, lighting, hot water, and other electrical appliances. In Indonesia, most high-rise hotel buildings still rely on conventional energy sources, leading to increased electricity consumption. There is a pressing need for energy-saving technologies in building design to ensure future sustainability. This includes simulating energy use intensity (EUI) and employing methodologies like Building Information Modeling (BIM) and Building Energy Modeling (BEM) to optimize energy efficiency.

An effective energy management system (EMS) integrates planning, operation, and supervision to maximize energy efficiency. Key factors include building orientation, envelope treatment, sun shading, and cooling load management. Energy savings are influenced by occupant behavior and building operations, such as air conditioning performance and usage schedules. Additionally, thermal comfort in hotel buildings, determined by factors like air temperature and humidity, plays a critical role in energy strategy.

This study highlights the urgency of implementing energy management strategies in hotels, particularly in Indonesia, to achieve energy savings and sustainability. The research questions focus on the impact of planning, operation, and supervision on energy renewability, cooling load, and thermal comfort in hotel buildings.

2. Method

This research is a type of quantitative research. The data from the research results need to be analyzed to be presented into a research result. Data analysis is a very important part of the scientific method. Therefore, to answer the problems and objectives of the research, descriptive statistical analysis, inferential statistical analysis and SEM analysis using the Partial Least Square (PLS) method are used.

3. Result and Discussion

Planning

The planning observed in this study is distinguished from the simulation result system and the real system applied to five multi-storey hotel buildings. Planning of the results of energy management simulations based on existing data on cooling load (target 25°C, humadity 60%) in the five observed hotels.

Table 1. Existing Data on Cooling Load Variation in Sun Shading Dimensions in the Hotel Building

Room	Hotel Clarion	Hotel Aryaduta	Hotel Sahid Jaya	Hotel Swissbel	Hotel Aston
1	4475	5632	4029	13107	7121
2	4313	4744	4643	5881	6903
3	3610	5000	4220	9113	4171
4	4137	4569	3913	13607	4666
5	5129	5799		5824	
6	4140	4785			
7	3845				
8	4300				
9	4536				

The following is shown the data of sun shading size variations in the table below:

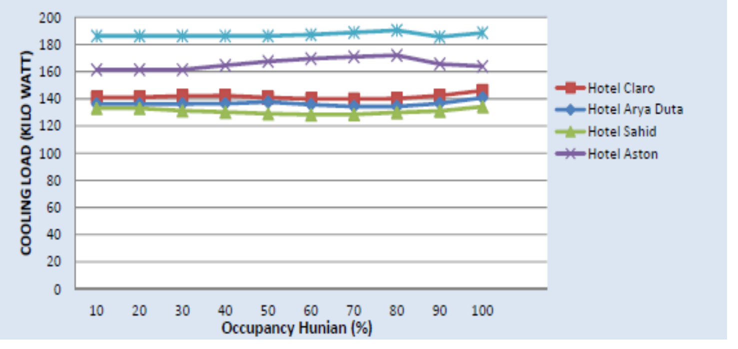
Table 2. Simulation of Sun Shading Size Variation (cm)

Hotel	Cooling load (target 25°C, *humadity* 60%)		
	Size Variations *Sun Shading* (cm)	Watt	%
Hotel Grand Clarion	260	3398	-17.9
Hotel Aryaduta	260	4140	-17.2
Hotel Sahid Jaya	220	3515	-16.7
Hotel Swissbel	240	6586	-27.7
Hotel Aston	10	4486	-3.9

Based on the planning of the simulation results, it is seen that after the addition of the variation in the size of the sun shading, it is known that the Grand Clarion Hotel of 260 cm with a cooling load of 3398 watts decreased by 17.9%, the Aryaduta Hotel by 260 cm with a cooling load of

4140 watts decreased by 17.2%, the Sahid Jaya Hotel by 220 cm with a cooling load of 3515 watts decreased by 16.7%, Swissbel Hotel by 240 cm with a cooling load of 6586 watts decreased by 27.7%, and Aston Hotel by 10 cm with a cooling load of 4486 watts decreased by 3.9%. The results of the comparison of the five hotels show that the highest rate of decline is the Swissbel Hotel with a sun shading dimension of 2.6 m, and the lowest one is the Aston Hotel with a sun shading dimension of 0.1 m.

The following is a resume of cooling load with occupancy variations in the five hotel buildings observed as shown in the following graphs and data:



OCCUPANCY HUNIAN (%)	COOLING LOAD (WATT/m²)				
	Hotel Claro	Hotel Arya Duta	Hotel Sahid	Hotel Aston	Hotel Swiss Bell
10	141.1	136.2	133	161.4	186.2
20	141.1	136.2	133	161.4	186.2
30	142.1	136.2	131.2	161.4	186.2
40	142.3	136.4	130.2	164.6	186.2
50	140.9	137.6	129	167.5	186.2
60	139.9	135.7	128.3	169.5	187.2
70	139.8	134.3	128.5	170.9	188.8
80	140.1	134.3	129.9	172	190.4
90	142.4	136.6	131	165.6	185.6
100	146	140.8	134.2	163.9	188.5

Figure 1. Cooling Load Resume Chart with Occupancy Variations for the Five Observed Hotel Buildings

The data graph above shows that the cooling load at the Clarion Hotel is the highest, which is 146 watts/m2 at 100% occupancy, and the lowest is 139.8 watts/m2 at 70% occupancy.The cooling load at the Aryaduta Hotel is the highest, which is 140 watts/m2 at 100% occupancy, and the lowest is 134.3 watts/m2 at 70% and 80% occupancy. The cooling load at Hotel Sahid Jaya is the highest at 134.2 watts/m2 at 100% occupancy, and the lowest is 128.3 watts/m2 at 60% occupancy.The cooling load at the Swissbell Hotel is the highest which is 190.4 watts/m2 at 80% occupancy, and the lowest is 186.2 watts/m2 at 20% to 50% occupancy. The cooling load at Aston Hotel is the highest at 170.9 watts/m2 at 70% occupancy, and the lowest is 161.4 watts/m2 at 10% and 30% occupancy.

Operation

The energy management of hotel buildings by implementing operations is adjusted to the performance of energy-efficient air conditioners applied through conservation measures in the air conditioning system, namely by regulating the air conditioning temperature at 25°C. Every 1°C temperature increase will save energy use on the air conditioner by 1–6%. If the initial temperature setting is changed to 25°C, it is assumed that there will be a decrease in consumption of at least 6%. This business should be considered considering that it does not cost at all, but reduces energy consumption and results in cost savings.

Table 3. Recapitulation of Energy Management Simulation Results

Operation	Highest	Lowest	Information
AC Performance (power/kWh)	60.911	6.080	Highest: Clarion Hotel Lowest: Hotel Sahid Jaya
Reduced AC On Time (cost savings of Rp/year)	14.602 billion	3.9 Million	Highest: Clarion Hotel Lowest: Aston Hotel
Changes in Air Conditioning Off Hours (cost savings of Rp/year)	7.301 Billion	1.9 million	Highest: Clarion Hotel Lowest: Aston Hotel
Setting Temperatur AC (cost savings of Rp/year)	14.602 billion	3.9 Million	Highest: Clarion Hotel Lowest: Aston Hotel

Supervision

Air conditioning (AC) is a common and essential device in most hotel buildings, working by cooling room air through the conversion of refrigerants like CFCs, HCFCs, or FCs from liquid to gas. This process absorbs heat, which is then released outside the room. In hotels, AC units often run 24 hours a day, but their use is typically adjusted according to the presence of occupants. Energy conservation can be achieved if guests cooperate in using ACs only when necessary.

Different hotels use various types of AC systems, such as central air conditioners, multi-V systems, split ACs, ducting systems, and standing floor units. However, not all are energy-efficient. To enhance energy savings, hotels should opt for efficient systems like VRV (Variable Refrigerant Volume) or Multy V air conditioners. These systems are equipped with central CPUs, inverter compressors, and other technologies that improve energy efficiency, durability, and overall performance, using one outdoor unit to serve multiple indoor units simultaneously.

Table 4. Recapitulation of the Results of Hotel Building Energy Management Simulation

Supervision	Use	Information
Air conditioning equipment (pk)	The air conditioning equipment for hotel rooms is pk1 and pk2	5 Observation Hotels
Energy Saving Strategy	Low Watt and Inverter	5 Observation Hotels

In the five hotels observed, energy management focused on air conditioning (AC) equipment, primarily using 1 pk and 2 pk units with energy-saving strategies like selecting low-wattage and inverter ACs. The energy strategy is based on cooling load and thermal comfort, involving air dispersion to achieve the required temperature and humidity in hotel rooms. The study evaluates energy efficiency in AC systems by calculating both external and internal heat loads. External heat load considers factors like roof, walls, glass, partitions, and floors, while internal heat load accounts for occupants, lighting, and electrical equipment. These calculations determine the cooling capacity (TR) required for each hotel room.

Energy Renewal

In general, the energy renewability system in multi-storey hotel buildings has met the SNI 6390-2011 standard with a temperature ranging from 24-26°C with a humidity value range of 56-65%. The level of comfort in a room is very important to support the functions of the room in the hotel building. The comfort level in question is an expression of the air condition represented by at least two air properties in the room, namely temperature and humidity. Meanwhile, the room temperature level inside the hotel building is 25.5°C ±1.5°C (24–27°C) and the air humidity is 60% ±5% (55–65%).

Cooling Load

Energy renewability systems in multi-storey hotel buildings require cooling loads that are in accordance with the influence of external and internal heat loads. The external heat load is highly determined by conduction, radiation and convection in determining the level of room heat sensitivity (Btu/h) according to the area of the roof, walls, glass, partitions, sky, floor and direct glass. Meanwhile, internal heat is affected by the occupants, lights and equipment in the room. The cooling load based on the external and internal heat load determines the cooling capacity (ton of refrigreration – TR).

Thermal Comfort

The energy strategy to obtain thermal comfort in a multi-storey hotel building, calculated based on the effective air temperature index, conducted a predicted mean vote (PMV) to indicate the feeling of coolness and warmth felt by hotel guests, then predicted the percentage of dissatisfaction using a predicted percentage of dissatisfied (PPD). The results of the energy strategy for thermal comfort based on TR, ITE, PMV and PPD are summarized in the table below:

Table 5. Recapitulation of the Results of the Simulation of the Energy Renewable System Strategy

Hotel Buildings in Makassar City

Energy Strategy	Highest	Lowest	Information
TR (ton)	5.131	0.370	Highest: Aston Hotel Lowest: Hotel Sahid Jaya
ITE (°C)	33.659	25.125	Highest: Swissbell Hotel Lowest: Aston Hotel
PMV	2.97	2.00	Highest: Swissbell Hotel Lowest: Hotel Aryaduta
PPD (%)	99.0	81.5	Highest: Swissbell Hotel Lowest: Hotel Aryaduta

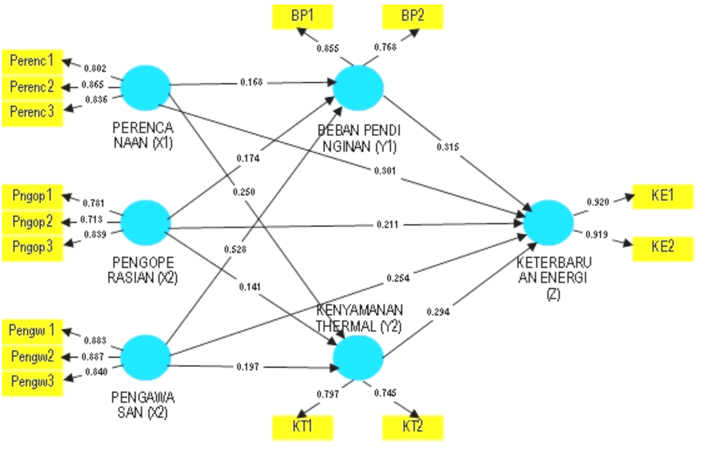
Overall, of the five hotels observed, the analysis of the energy-saving strategy of the hotel building air conditioning system seen from the highest TR (ton) is the Aston Hotel and the lowest is the Sahid Jaya Hotel. Judging by the ITE (°C) the highest is the Swissbell Hotel and the lowest is the Aston Hotel. Furthermore, the highest PMV is Swissbell Hotel and the lowest is Aryaduta Hotel. While the highest PPD (%) is Swissbell Hotel and the lowest is Aryaduta Hotel.

Analisis Structural Equation Model Partial Least Square (SEM-PLS)

The analysis technique used to interpret and analyze the data in this study is Structural Equation Modeling Partial Least Square (SEM-PLS) which is operated through the Smart PLS program version 3.0

Outer Testing

The outer model analysis model defines how each indicator relates to its latent variable. As for the measurement model for the validity and reliability test, the model determination coefficient and the path coefficient for the equation model, can be seen in the following figure:



Gambar 1. Covergent Validity

Covergent Validity

The Convergent Validity value is the value of the loading factor on the indicator with its statement. Convergent Validity is used to determine the validity of each indicator in this study. The expected value exceeds 0.7 as the minimum limit of the loading factor value. The following is a table of covergent validity values.

Table 6. Covergent Validity Value

Variable	Indicator	Outer Loading Value
Planning	X11	0.802
	X12	0.865
	X13	0.836
Operation	X21	0.781
	X22	0.713
	X23	0.839
Supervision	X31	0.883
	X32	0.887
	X33	0.840
Cooling Load	Y11	0.855
	Y12	0.768
Thermal Comfort	Y21	0.797
	Y22	0.745
Energy Renewal	Z11	0.920
	Z11	0.919

From the data in Table 6, it is known that the overall value of the outer loading indicator is valid by obtaining a value above 0.7, so there is no need to retest.

Average Variance Extracted (AVE)

The Average Variance Extracted (AVE) value is used to determine whether the latent variable has adequate discrimination, namely by comparing the correlation of the indicator with the latent variable must be greater than the correlation between the indicator and other variables. If the correlation of the indicator with its latent variable has a higher value compared to the correlation of the indicator with other latent variables, then it can be said that the latent variable has high validity. The standard AVE value is >0.5. The Average Variance Extracted (AVE) values for each variable are as follows:

Tabel 7. Nilai Average Variance Extracted (AVE)

No	Variable	AVE Scores
1	Planning (X1)	0.675
2	Operation (X2)	0.800
3	Surveillance (x3)	0.666
4	Cooling Load (Y1)	0.707
5	Thermal Comfort (Y2)	0.697
6	Energy Renewal (Z)	0.752

Composite Reliability

To test the constructed being studied, a composite reliability test was also carried out. This test is to measure internal consistency and the value must be above 0.7. The composite reliability value of each variable in this study can be seen in the following table 8:

Tabel 8 Nilai Composite Reliability (CR)

No	Variable	CR Value
1	Planning (X1)	0.892
2	Operation (X2)	0.923
3	Surveillance (x3)	0.881
4	Cooling Load (Y1)	0.888
5	Thermal Comfort (Y2)	0.881
6	Energy Renewal (Z)	0.915

The data in Table 8 shows that the composite reliability value obtained by each variable is above 0.7. Thus, it can be concluded that all constructs have good reliability according to the required minimum value limit.

Cronbach's Alpha

The reliability test is also seen from the Cronbach Alpha value of each variable. The expected value is ≥ 0.6 for all constructs. The results of the outer PLS for the cronbach alpha value can be seen in the following table:

Table 9. Cronbach Alpha (CA) Values

No	Variable	CA Value
1	Planning (X1)	0.841
2	Operation (X2)	0.878
3	Surveillance (x3)	0.835
4	Cooling Load (Y1)	0.859
5	Thermal Comfort (Y2)	0.830
6	Energy Renewal (Z)	0.875

Based on Cronbach's alpha value in Table 9, it is known that the value obtained for each variable is above the value of 0.60. Thus, it can be concluded that all constructs have a good Cronbach's alpha value because they are qualified.

Testing the Structural Model (Inner Model)

The structural model in PLS is evaluated using the value of the path coefficient for the independent variable which is then assessed for significance based on the t-statistic value of each path. The structural model of the research based on the results of the bootstrapping test can be seen in the following figure:

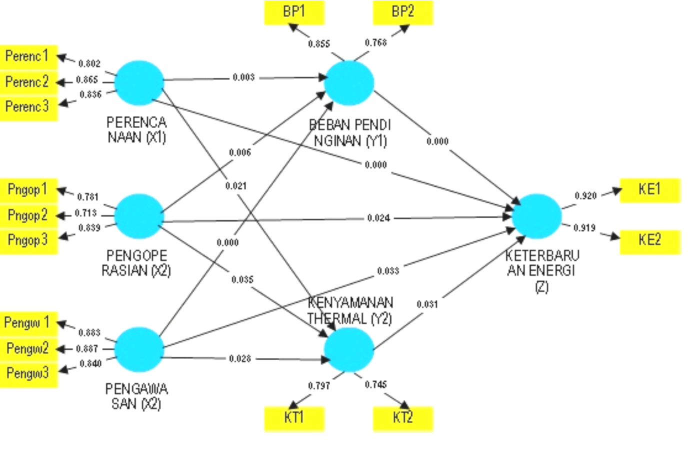


Figure 2. Bootstrapping Test Results

To assess the significance of the prediction model in structural model testing, it can be seen from the p values between exogenous variables to endogenous variables in the following table:

Table 10. Path Coefficient

No	Variable	Original Sample	Sample Mean	Standard Deviation	Value t	Sig Value.
1	Planning for Cooling Load	0.168	0.168	0.060	2.815	0.003
2	Operation against Cooling Load	0.174	0.182	0.070	2.496	0.006
3	Supervision of Cooling Load	0.528	0.529	0.078	6.809	0.000
4	Planning for Thermal Comfort	0.250	0.243	0.122	2.048	0.021
5	Operation of Thermal Comfort	0.141	0.139	0.078	1.812	0.035
6	Supervision of Thermal Comfort	0.197	0.211	0.103	2.018	0.028
7	Planning for Renewable Energy	0.301	0.303	0.081	3.728	0.000
8	Operation towards Renewable Energy	0.211	0.204	0.078	2.184	0.024
9	Supervision of Renewable Energy	0.254	0.249	0.115	1.921	0.033
10	Cooling Burden on Energy Renewables	0.315	0.308	0.085	3.185	0.000
11	Thermal Comfort for Energy Renewal	0.294	0.215	0.103	2.451	0.031

The data in table 10 shows the direct influence of the independent variable on the mediation variable and the bound variable. It can be seen that the highest direct influence is the monitoring variable on the cooling load with a t-value of 6.809 and a significance value of 0.000. The lowest direct influence was the operating variable on thermal comfort with a t-value of 1.812 and a significance value of 0.035.

Tabel 11. Spesific Indirect Effects

No	Variable	Original Sample	Sample Mean	Standard Deviation	Value t	Sig Value.
1	Planning for Energy Renewal through Cooling Load	0.052	0.054	0.025	2.112	0.018
2	Operation towards Energy Renewal through Cooling Load	0.075	0.074	0.044	1.699	0.045
3	Supervision of Energy Renewal through Cooling Load	0.059	0.064	0.038	1.761	0.039
4	Planning for Energy Renewal through Thermal Convenience	0.062	0.064	0.035	2.223	0.012
5	Operation towards Energy Renewal through Thermal Convenience	0.085	0.084	0.054	1.799	0.030
6	Supervision of Energy Renewal through Thermal Convenience	0.072	0.074	0.048	1.671	0.046

The data in table 11 shows the indirect influence of the independent variable on the bound variable through the mediation variable. It can be seen that the highest indirect influence is the planning variable on energy renewability through thermal comfort with a t-value of 2.223 and a significance value of 0.012.

Nilai R Square (R2)

The R Square value (R2) indicates the degree of determination of the exogenous variable to its endogenous. A larger R2 value indicates a better level of determination. The value of R square can be seen in the following table:

Table 12. R Square Value

No	Variable	R Square	R Adjusted Square
1	Energy Renewal	0.679	0.664
2	Cooling Load	0.189	0.161
3	Thermal Comfort	0.685	0.679

Based on the R square value in Table 12, it can be concluded that the value of the determination coefficient of the energy renewability variable is 0.679. This value explains that the contribution of planning, operation and supervision variables in explaining energy renewability is 67.9% and the remaining 32.1% is explained by other factors that are not involved in this study. The value of the determination coefficient of the cooling load variable was 0.189, explaining that the contribution of the planning, operation and supervision variables in explaining the cooling load was 18.9% and the remaining 81.1% was explained by other factors that were not involved in this study. Similarly, the determination of the thermal comfort variable was 0.685, explaining that the contribution of planning, operation and supervision variables in explaining thermal comfort was 68.5% and the remaining 31.5% was explained by other factors that were not involved in this study.

4. Conclusion

The results of the analysis and discussion concluded that planning, operation and supervision as a form of energy management implementation showed a target cooling load of 25°C and a humandity of 60%, the existing conditions of windows, glass and sun shading were different according to the orientation of the hotel, some had the highest and lowest cooling loads, the cooling load could decrease depending on the dimensions of horizontal and vertical sun shading, glass openings extending from top to bottom and double glass. Furthermore, based on the calculation of external and internal cooling loads, TR was obtained from 0.370 tons to 5.131 tons, with thermal comfort based on ITE of 25.1 °C to 33.6 °C, PMV calculation results obtained from 2.00 to 2.97, and PPD calculation results of 81.5% to 99%. This indicates that the hotel building has implemented an energy strategy by using low wattage air conditioners and inverters. This is in accordance with the results of SEM-PLS analysis, the variables of planning, operation and supervision directly have a significant influence on cooling load, thermal comfort and energy renewability. Likewise, the cooling load and thermal comfort directly have a significant effect on energy renewability. For the analysis of the overall specific indirect effect, the planning, operation and supervision variables have a significant effect on energy renewability through cooling load and thermal comfort. This means that energy renewability is determined by the implementation of energy management starting from planning, operation and supervision as well as the calculation of cooling loads and thermal comfort.

5. References

Zaixun Ling, Yibo Cui, Jingwen Zheng, Yu Guo, Wanli Cai, Xiaofei Chen, Jiaqi Yuan, and Wenjie Gang, 2021. Design Optimization and Comparative Analysis of 100% Renewable Energy Systems for Residential Communities in Typical Areas of China When Considering Environmental and Economic Performance. Sustainability 2021, 13, 10590. https://doi.org/10.3390/su131910590.

Hussein M. Maghrabie, Mohammad Ali Abdelkareem, Abdul Hai Al-Alami, Mohamad Ramadan, Emad Mushtaha, Tabbi Wilberforce 8 and Abdul Ghani Olabi, 2021. State of the Art Technologies for Building-Integrated Photovoltaic Systems. Buildings 2021, 11, 383. https:// doi.org/10.3390/buildings11090383.

Oscar Lindholm, Hassam Ur Rehman and Francesco Reda, 2021. Positioning Positive Energy Districts in European Cities. Buildings 2021, 11, 19. https://doi.org/10.3390/buildings11010019.

Luis Martin, Fatima Maciel dan Maria Caroline, 2021. Energy Efficiency Indicators for Hotel Building. Sustainability, 13(4), 1754; https//doi.org/10.3390/su130417.

Ds Gao, H.; Koch, C.; Wu, Y. Building information modelling based building energy modelling: A review. Appl. Energy 2019, 238, 320–343.

Gerrish, T.; Ruikar, K.; Cook, M.J.; Johnson, M.; Phillip, M. Using BIM capabilities to improve existing building energy modelling practices. Eng. Constr. Arch. Manag. 2017, 24, 190–208.

Jorge González, Carlos Alberto Pereira Soares, Mohammad Najjar and Assed N. Haddad, 2021. BIM and BEM Methodologies Integration in Energy-Efficient Buildings Using Experimental Design. Buildings 2021, 11, 491. https://doi.org/10.3390/buildings11100491.

Hansen, K.; Mathiesen, B.V.; Skov, I.R. Full energy system transition towards 100% renewable energy in Germany in 2050. Renew. Sust. Energ. Rev. 2019, 102, 1–13.

Lund, H.; Mathiesen, B.V. Energy system analysis of 100% renewable energy systems—The case of Denmark in years 2030 and 2050. Energy 2019, 34, 524–531.

Headley, A.J.; Copp, D.A. Energy storage sizing for grid compatibility of intermittent renewable resources: A California case study. Energy 2020, 198, 117310.

Feng, T.-T.; Li, R.; Zhang, H.-M.; Gong, X.-L.; Yang, Y.-S. Induction mechanism and optimization of tradable green certificates and carbon emission trading acting on electricity market in China. Resour. Conserv. Recycl. 2021, 169, 105487.

Qi, M.; Shi, Y.; Li, X. A Bottom-up Method to Assess Energy Consumption of Main Departments in Five-star Hotels in China. In Proceedings of the 15th IBPSA Conference, San Francisco, CA, USA, 7–9 August 2017; pp. 1347–1357.

Sheng, Y.; Miao, Z.; Zhang, J.; Lin, X.; Ma, H. Energy consumption model and energy benchmarks of five-star hotels in China. Energy Build. 2018, 165, 286–292.

Huang, K.T.; Wang, J.C.; Wang, Y.C. Analysis and benchmarking of greenhouse gas emissions of luxury hotels. Int. J. Hosp. Manag. 2016, 51, 56–66.

Oluseyi, P.O.; Babatunde, O.M.; Babatunde, O.A. Assessment of energy consumption and carbon footprint from the hotel sector within Lagos, Nigeria. Energy Build. 2016, 118, 106–113.

Pieri, S.P.; Tzouvadakis, I.; Santamouris, M. Identifying energy consumption patterns in the Attica hotel sector using cluster analysis techniques with the aim of reducing hotels' CO2 footprint. Energy Build. 2016, 94, 252–262.

Tang, M.; Fu, X.; Cao, H.; Shen, Y.; Deng, H.; Wu, G. Energy performance of hotel buildings in Lijiang, China. Sustainability 2016, 8, 780.

Anh Tuan Nguyen, 2019. Developing an Energy Benchmarking System For Hotel Building Using the Statistical Method and the Simulation-Based Approach. Journal of Green Building 14(3)1-2, DOI:10.3992/1943-4618.14.3.1.

Teng, Z.R., Wu, C.Y., and Xu, Z,Z, 2017. New Energy Benchmarking Model for Budget Hotels, International Journal of Hospitality Management, 67. 62-71.

Mikhak Samadi, 2021. Energy Use Intensity Disaggregation in Institutional Buildings – A Data Analytics Approach. Journal of Energy and Buildings, Volume 235, 15 March 2021, 110730.

Syarifuddin, Ashar Saputra dan Suprapto Siswosukarto, 2018. An Analysis of Energy Consumption in the Campus Building's Operation (Case Study: The Building of Faculty of Engineering and Department of Civil and Environmental Engineering, University Gadjah Mada). Journal of the Civil Engineering Forum 4(1).61. DOI: 10.22146/jcef.27642.

Seok Hyun Kin, Kyung Ju Shin, Hyo Jun Kim and Young Hum Cho, 2017. A Study on the Effectiveness of the Horizontal Shading Device Installation for Passive Control of Buildings in South Korea. Research Article ID 3025092. Volume 2017, https://doi.org/10.1155/2017/3025092.

Labeodan, T; Zeller, W; Boxem G; Zhao, Y. 2015. Occupancy Measurement in Comercial Office Buildings for Demand-Drivin Control Applications – A Survey and Detection System Evaluation. Journal of Energy Build, Volume 93. 303-314.

Chairani, S. Sulistyo and Widyawan, 2017. Cooling Load Estimation in the Building Based on Heat Source. International Conference on Environmental and Energy Engineering (IC3E) IOP Publishing 63(2017)012052 DOI: 10.1088/1755.1315/63/1/012052.

Yamile Diaz Torres, 2016. Application of Building Energy Simulation in the Validating of Operational Strategies of HVAC Systems on a Tropical Hotel. Ingenieria Mechanica, Vol. 20 No. 1. Instituto Superior Politecnico.

Aiman Albatayneh, 2021. Optimising the Parameters of a Building Envelope in the East Mediterranean Saharan, Cool Climate Zone. Buildings 2021, 11, 43. https://doi.org/10.3390/buildings11020043.

Mohammad Nyme Uddin, Hsi-Hsien Wei, Hung Lin Chi and Meng Ni, 2021. Influence of Occupant Behavior for Building Energy Conservation: A Systematic Review Study of Diverse Modeling and Simulation Approach. Buildings 2021, 11, 41. https://doi.org/10.3390/buildings11020041.

Yao, J. Modelling and simulating occupant behaviour on air conditioning in residential buildings. Energy Build. 2018, 175, 1–10.

Li, J.; Yu, Z.; Haghighat, F.; Zhang, G. Development and improvement of occupant behavior models towards realistic building performance simulation: A review. Sustain. Cities Soc. 2019, 50.

Philip Gorzalka, Jacob Estevan Schmiedt, Christian Schorn and Bernhard Hoffschmidt, 2021. Automated Generation of an Energy Simulation Model for an Existing Building from UAV Imagery. Buildings 2021, 11, 380. https://doi.org/10.3390/buildings11090380.

Sola, A.; Corchero, C.; Salom, J.; Sanmarti, M. Multi-domain urban-scale energy modelling tools: A review. Sustain. Cities Soc. 2020, 54, 101872

Rand Talib and Nabil Nassif, 2021. “Demand Control” an Innovative Way of Reducing the HVAC System’s Energy Consumption. Buildings 2021, 11, 488. https://doi.org/10.3390/buildings11100488.

Jee-Heon, K.; Seong, N.-C.; Choi,W. Forecasting the energy consumption of an actual air handling unit and absorption chiller using ANN models. Energies 2020, 13, 4361.

Jihong Zhu and Deying Li, 2015. Current Situtation of Energy Consumption and Energy Saving Analysis of Large Public Building. Journal Procedia Engineering 121(2015)1208-1214, DOI: 10.1016/j.proeing.2015.09.140.

Seihun Yang, Weiming Chen and Hana Kim Building Energy Commons: Three Mini-PV Installation Cases in Apartment Complexes in Seoul. Energies 2021, 14, 249. https://doi.org/10.3390/en14010249.

Antima Sharma and Namrata Sengar, 2019. Heat Gain Study of a Residential Building in Hot-Dry Climate Zone on Basis of Three Cooling Load Methods. EJERS, European Journal of Engineering Research and Science Vol. 4, No. 9, DOI: http://dx.doi.org/10.24018/ejers.2019.4.9.1508.

M. Baneshi, H. Gonom, S. Maruyama, 2016. Cool black roof impacts into the cooling and heating load demand of a residential building in various climates Energy Materials & Solar Cells, vol.152, pp 21–33.

Eng. E. S. Ben, 2018. Cooling and heating loads in residential buildings in Kuwait, Journal of Engineering Research and Application, ISSN: 2248-9622, Vol. 8, pp 01-14, Issue5 (Part -V).

Nasrullah Sahid, Ramli Rahim, Baharuddin Hamzah and Rosady Mulyadi, 2019. Analysis of Indoor Thermal Comfort of Room Space in the International Standard Hotel Building. Advances in Social Sciences Research Journal Vol. 6 No. 2. DOI: 10.14738/assrj.62.6195.

Kyriaki, E. Drosou V, and Papadopoulus AM, 2015. Solar Thermal System for Low Energy Hotel Building State of the Art, Perspective and Challenges. Energy Procedia, 78.1968-1973.

Zhang, Z, MA, C and Zhu R, 2018. Thermal and Energy Mangement Based on Bimodal Airflow-Temperature Sensin and Reinforcement Learning. Energies, 11 (10) 2575, https://DOI:10.3390/en11102575.

Ke Liu, Beili Zhu and Jianping Chen, 2021. Low-Carbon Design Path of Building Integrated Photovoltaics: A Comparative Study Based on Green Building Rating Systems. Buildings 2021, 11, 469. https://doi.org/10.3390/buildings11100469.

Marwa M. Gomaa Mayhoub, Zeyad M. Tarek El Sayad, Ahmed Abdel Monteleb M. Ali and Mona G. Ibrahim, 2021. Assessment of Green Building Materials’ Attributes to Achieve Sustainable Building Façades Using AHP. Buildings 2021, 11, 474. https://doi.org/10.3390/buildings11100474.