CONSTRUCTION
E-ISSN: 2785-8731
VOLUME 5, ISSUE 1, 2025, 123 - 128
DOI: https://doi.org/10.15282/construction.v5i1.12218

RESEARCH ARTICLE

Active Design Features in Hot-Humid Countries: Summary of a Survey

Md M. Rahman*, N. A. Haji Juffle and R. A. Asli

Civil Engineering Programme Area, Universiti Teknologi Brunei, Gadong BE1410, Brunei Darussalam

ABSTRACT - Although passive design strategies considerably reduce building energy consumption and CO_2 emission, they cannot be used alone, as they rely on the sun and wind, which may not always maintain comfortable ambient temperature during different times of the day, season and year. Various active design features are therefore used to complement the situation. This requires practicing suitable active features that match the underlying climate of different regions/countries. As such, the aim of this study was to identify the practice of various active design features for buildings in hot-humid countries like Brunei. A quantitative questionnaire survey of 122 responses from construction industry participants was used. It was observed that seven of the commonly known eight active features are seen to be consistently practiced in Brunei, with the priority of electric lighting system, heating, ventilation and air conditioning, and electric fans. Although practicing these features are not sustainable, such priority might have the roots in relatively much lower energy price. Moreover, some more sustainable active features are practiced less frequently or of low priority, like solar panels, cool roof technology, and heat pump technology. These may be more preferred in some other countries, with high energy price. Respondents are not sure about the application of only one active feature: operable louvers or blinds, probably due to lack of information and knowledge. Similar priority was observed in different groups based on affiliation and profession. The only disagreements observed on the level of importance of two active features by the groups based on affiliation, although the features were seen consistently important in all the groups. The overall results were interpreted as a lack of awareness and information on the sustainability aspect of using energy, as respondents preferred less-sustainable active features due to low energy price. Policy makers are expected to use the outcomes in devising suitable programs and regulation, towards practicing more sustainable design features of buildings in hot-humid countries.

ARTICLE HISTORY

Received	:	25th Mar. 2025
Revised	:	24th May 2025
Accepted	:	11th June 2025
Published	:	10th June 2025

KEYWORDS

Active design features
Brunei
Hot-humid countries
Sustainable design

1. INTRODUCTION

Building sector critically impacts on climate change, as it globally consumes the highest energy of up to 40% and emits also up to about 40% of carbon-di-oxide (CO_2) [1, 2]. These are even higher in many developing countries or emerging economies, due to the increase in population and faster urbanization [3]. Many such energy consuming and CO_2 emitting countries are in hot and humid [i.e. hot-humid] region, like Indonesia, Thailand, Philippines and Malaysia [4, 5, 6]. In order to reduce such energy consumption, UNEP (United Nations Environment Program) suggested adopting passive design strategy (PDS) in buildings [2], which uses the two natural phenomena of the sun and wind, in adapting different building features to considerably reduce energy consumption and CO_2 emission, and which applies both for heating/cooling and lighting [7]. Such PDS features include orientation, aspect ratio, solar panels, insulation, shading panels, green roofs, and many more [8].

PDS offers numerous environmental and economic benefits, including: 30% reduction of energy consumption and 25% reduction of CO_2 emissions [9]; 20% reduction of building operational costs [10]; and reduction of energy expenses of 25% to 40% [11, 12]. Despite such demonstrated effectiveness, PDS alone is insufficient to fully allow occupants' well-being and comfort in hot-humid climates [13, 14]. The main reasons are: natural light from the sun is available only during day times, ambient temperature is higher than human comfort levels [15], and insufficient availability of wind [16]. Moreover, both the ambient temperature and wind considerably vary during different times of the day, which may be much higher or insufficient for human comfort levels, respectively [17]. Furthermore, human comfort levels vary from person to person, meaning some people may feel comfort with slightly higher room temperature, while others may require relatively low room temperature for their comfort [18, 19]. As such, active design solutions through mechanical devices are required, which use externally supplied energy (i.e. electricity and natural gas), such as ceiling fan, air conditioner and electric lighting [20]. Active design solutions also include features like heat pumps, radiant heating, wind turbines, heat recovery ventilators and solar panels, which either use ambient energy and wind, or taps energy from the nature and use when necessary [21]. Although, such active design solutions involve spending additional money for purchasing externally supplied energy [20], they are undeniably required, and form parts of sustainable solutions, both for the optimal performance of buildings, and occupants' comfort requirements [22, 23].

***CORRESPONDING AUTHOR | M.M. Rahman** | ✉ motiar.rahman@utb.edu.bn

In view of the above, and as far as this study is concerned, both passive and active design strategies together were referred to as sustainable design (SusD). As such, a study was undertaken to identify the suitability of various SusD (i.e. active and passive design) features in hot-humid countries in general, considering Brunei as a test bed. The overall study included identifying importance of various roles in deciding adoption of SusD, and suitability of various passive and active design features, through a questionnaire survey. However, this paper specifically focuses on identifying suitability of various active design features. The findings of this study are expected to facilitate the implementation of environmentally conscious active design practices in buildings. It is also expected to offer valuable insights for professional service providers (such as architects and structural engineers), policymakers, government departments, and other relevant stakeholders towards conscious practice of suitable sustainable active design features in buildings. promote the adoption of SusD in construction projects and urban development initiatives.

2. RESEARCH METHODOLOGY

A structured literature review (SLR) was conducted in three academic listings of Taylor and Francis, Science Direct and Emerald Insight, using five relevant keywords, that initially identified 1,713 articles. However, filtering of the repeated title and keywords reduced the number of papers to 261. The papers were then scanned for their primarily focus on reduced energy consumption and CO_2 emissions, and relevance to PDS. Eventually 156 papers were found to deal with hot-humid climates, which were considered for review.

The extracted features included eight (8) active design features, that were included in a structured questionnaire. A total of 399 questionnaires were distributed, randomly selecting from the lists maintained by the ministry and public works departments, with 133 to each group of clients, consultants and contractors. The questionnaire was distributed both by email with the link of the online questionnaire and attaching the Word file, as well as handing in the hard copy by visiting the company offices. This produced 122 responsive responses registering over 30% rate of response. The respondents expressed their perceptions on suitability of the eight active features on a Likert scale of 1 to 5: 1 as 'the least suitable', 2 is 'less suitable', 3 is 'average', 4 is 'more suitable' and 5 as 'the most/best suitable'. In terms of affiliation of the respondents, there were 23 contractors, 29 clients and 70 consultants. In terms of profession, there were 27 architect, 37 manager and 58 engineer respondents.

Data was analyzed using the Statistical Package for Social Sciences (SPSS) software. The Cronbach's alpha was calculated as: $\alpha = (N*C) / (v+(N-1)*C)$, with α as the coefficient alpha, N is the number of items, C is the covariance between item pairs, and v is the average covariance. The observed α value of 0.79 confirmed the reliability of the collected data, as values between 0.70 to 0.85 is considered very good [24]. The study used skewness and kurtosis for normality approximation. For distribution of any data set, skewness measures the asymmetry and kurtosis measures the 'tailedness'. Skewness is calculated as [= 3 (mean – median)/ standard deviation], and kurtosis is calculated as:

$$\text{kurtosis} = \frac{n(n+1)}{(n-1)(n-2)(n-3)} \frac{\sum (x_i - \bar{x})^4}{(\sum (x_i - \bar{x})^2)^2} - 3\frac{(n-1)^2}{(n-2)(n-3)}$$

where: n is the sample size, x_i are observations of the variable x, and $\bar{x}$ is the mean of the variable x [25]. Calculating skewness and kurtosis is laborious and time-consuming, so most people calculate these by using any scientific or computer software. As such, the values of skewness and kurtosis for this study were calculated using the SPSS software. The observed values were between −2 to +2, showing thus conformance to normal distribution [25]. The reliability test and normality test thus suggested parametric analysis [24, 25].

The mean scores of individual features were calculated, ranked and compared between the total sample and different groups of respondents. The t-test examined if the mean scores were significantly important, and ANOVA tested if the different respondent groups agreed on the importance levels of different features. Although these were calculated using the SPSS, the 't-values' for the 't-test' are calculated using the formula: $t = (\bar{x} - \mu) / (\sigma / \sqrt{n})$, where t is the t-value, $\bar{x}$ is the sample mean, μ is the population mean, σ is the sample standard deviation, and n is the sample size. On the other hand, the variances in ANOVA are calculated as: $s^2 = \sum (x_i - \bar{x})^2 / (n-1)$, where s^2 *is the variance,* x_i is *i*th observed data, i = 1, 2, 3, .. n, $\bar{x}$ is the sample mean, and n is the sample size.

3. RESULTS AND DISCUSSION

Table 1 presents the mean scores, ranks and significance obtained from t-tests of the eight active design features (that were used in the questionnaire survey) within the total sample. It is seen that the most commonly used active feature is 'application of electric lighting systems' (A1, rank 1), with a score of 4.37 (henceforth: A1: 1/4.37). This is followed by 'application of heating, ventilation and air conditioning (HVAC) systems' (A7: 2/4.27), and the 'use of evaporative cooling / electric fans' (A5: 3/3.86). All these three features are usually operated with externally supplied artificial energy or electricity, which are not sustainable. The reason behind this may link to the fact that energy price in Brunei is much cheaper than international tariff system [26]. This may also be indicative of a lack of awareness on sustainable energy use, which might be related to the lack of any government initiative towards sustainable practices for energy use, and/or lack of any clear policy and rules and regulations. 'Operable louvers/blinds' (A8: 4/3.16) ranks 4, and the scores of these four features are more than the average of the measuring scale (i.e. >3.00), indicating their general importance. Nevertheless, significance results from t-tests indicate that 'operable louvers/blinds' (A8) is the only insignificant active feature, implying that Brunei construction industry respondents are not sure about the use of this feature in Brunei, and consistently recommended the other seven active features are suitable, or being practiced in Brunei, with some are practiced more frequently than some others.

Table 1. Preference of active design features in total sample

Code: Description	Mean	Rank	Sig.
A1: Application of electric lightning systems /LED	4.37	1	0.000
A7: Application of HVAC system, e.g. air-conditioner	4.27	2	0.000
A5: Use of evaporative cooling (/electric ceiling fans)	3.86	3	0.000
A8: Application of operable louvers/blinds	3.16	4	0.158
A4: Use of solar technology to generate electricity	2.64	5	0.001
A6: Use of cool roof for cooling	2.52	6	0.000
A2: Use of solar tube to bring daylight inside	2.17	7	0.000
A3: Application of heat pumps technology	2.07	8	0.000

The scores of the remaining four active features (i.e. A4, A6, A2 and A3, with corresponding ranks from 5 to 8) are less than 3.00, indicating their 'less than average' use. This is clearly seen in Figure 1 that shows the trend of the preference of the features.

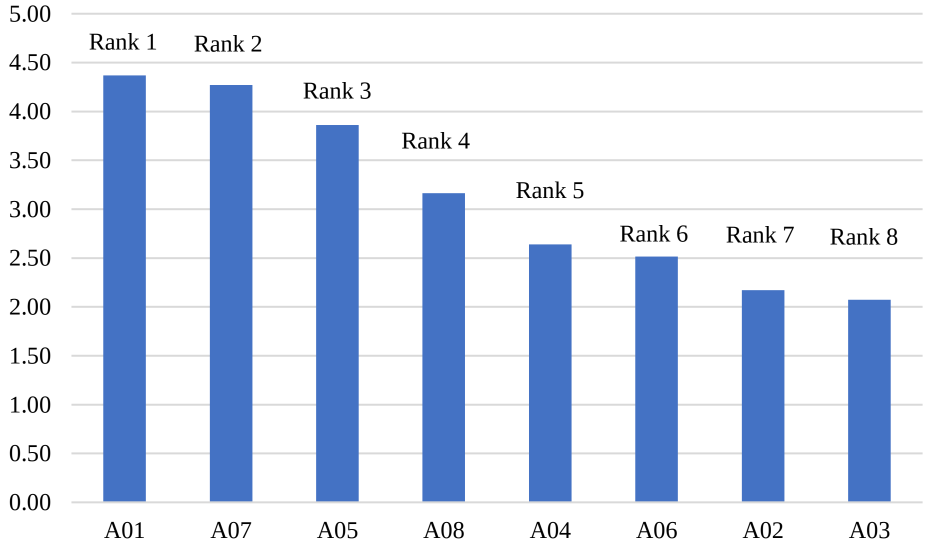

Figure 1. Trend of importance levels of the features

Although these four features are categorized in the 'active' features group, they are based on sound sustainable approach, and resemble to the passive principles, at least to some extent. For example, cool roof or green roof (A6: 6/2.52) technology uses vegetation of varying thickness on the roof-top, to protect the building from gaining heat from the sun. As a result, temperature inside the building remains relatively low, and this results in to reduced need for using any active features (such as A7: air conditioner, or A5: ceiling fan) to cool the room space. Similarly, heat pump technology (A3: 8/2.07) uses ambient temperature and keeps room cooler by circulating air. As mentioned above, 'less than average' score of these four features (i.e. A4, A6, A2, A3), and thereby their less practice, along with the prevailing habits of frequent use of more traditional electro-mechanical active features that are run with externally supplied energy (i.e. factors ranking 1-3), clearly indicate a lack of knowledge and awareness of the respondents, i.e. Brunei construction industry practitioners, along with relatively low energy price [9]. This may also need to motivating people by disseminating the benefits of the sustainable active approaches, such as 'cool' or green roof (A6) can potentially result in to energy savings ranging from 15% to 35.7% in buildings [27]. Clear preference on the use of externally supplied active design features is also indicative of lack of progress towards sustainable practices [28], and suggest requirement for focused awareness and education campaigns, to promoting more sustainable active features (i.e. A2-4, A6), and their inclusion in building codes [2, 3].

Table 2 compares the preference of the eight features between the groups according to the affiliation of the respondents, namely client, consultant and contractor. In order for easier comparison, the preferences by the groups have been arranged following the preference of the features in the total sample. The significance levels obtained from the t-tests show that most of the active features are significantly important within the three groups, except for a few features. All the three groups considered that 'operable louvers/ blinds' (A8) is insignificant or not suitable in Brunei, indicating their doubt on its usefulness or effectiveness. In addition to this, consultants group considered two more features as insignificant: use of solar panel (A4) and use of cool/green roof (A6). This is contrasting to the fact of procurement practice that consultant are considered as the source of wisdom for suggesting clients on adopting various sustainability practices, and this might happen due to the consistent lack of demand from the clients, as sustainable active features like solar panels require higher initial investment.

Table 2. Comparing the preference between affiliation groups

Code	Consultant			Contractor			Client			ANOVA
	Mean	Rank	Sig.*	Mean	Rank	Sig.*	Mean	Rank	Sig.*	
A1	4.23	1	0.000	4.30	2	0.000	4.76	1	0.000	0.028
A7	4.14	2	0.000	4.30	1	0.000	4.55	2	0.000	0.226
A5	3.81	3	0.000	3.65	3	0.018	4.14	3	0.000	0.268
A8	3.23	4	0.107	2.83	4	0.567	3.28	4	0.293	0.368
A4	2.80	5	0.163	2.43	5	0.020	2.41	5	0.006	0.198
A6	2.76	6	0.104	2.30	6	0.032	2.10	6	0.001	0.050
A2	2.36	7	0.000	2.26	7	0.012	1.66	8	0.000	0.028
A3	2.23	8	0.000	2.00	8	0.000	1.76	7	0.000	0.175

Sig.* - Significance obtained from t-tests.

The ranks of the individual features are seen similar to those in the total sample. The only exceptions are seen in contractor group for features A1 and A7 as they swapped the ranks of 1 and 2; and in the client group for features A2 and A3 as they swapped the ranks of 7 and 8. However, the ANOVA results indicated agreement among the three groups on the relative importance of all the active features, except for electric lighting systems (A1) and use of solar tubes to bring daylight inside the room (A2). These two features are significant both in total sample and by the three groups. Apparently, the disagreement came from the differences in the scores by the three groups. For example, the score of A1 by consultants is 4.23 by it ranked 1, compared to 4.30 by contractors with rank 2, and 4.76 by clients that ranked 1. On the whole, the results were interpreted as the higher level of agreement between the groups, suggesting a common understanding of the importance levels of most features, and despite slight differences in priority of a very few features.

Table 3 compares the preference between the three groups according to the nature of job or profession of the respondents, namely management, architectural and engineering. It is seen that the ranks of individual features are similar to those in the total sample. The only difference is by management group, in that the features A1 and A7 have exchanged their ranks. The significance obtained from the t-tests showed inconsistency of one feature (A8: operable louvers) in all three groups, ‘solar technology’ (A4) in engineering and architectural groups, and 'cool roof' (A6) in architectural group. As such, five features were seen consistent or significantly important in architectural group, six features were seen consistent or significantly important in engineering group, and seven features were seen consistent or significantly important in management group.

Table 3. Comparing the preference between profession groups

Code	Management			Architectural			Engineering			ANOVA
	Mean	Rank	Sig.*	Mean	Rank	Sig.*	Mean	Rank	Sig.*	
A1	4.54	2	0.000	4.33	1	0.000	4.28	1	0.000	0.378
A7	4.59	1	0.000	4.30	2	0.000	4.05	2	0.000	0.055
A5	4.05	3	0.000	3.78	3	0.000	3.78	3	0.000	0.463
A8	2.95	4	0.800	3.11	4	0.621	3.33	4	0.063	0.356
A4	2.54	5	0.017	2.59	5	0.070	2.72	5	0.081	0.729
A6	2.43	6	0.016	2.56	6	0.050	2.55	6	0.014	0.897
A2	2.22	7	0.000	2.26	7	0.007	2.10	7	0.000	0.831
A3	2.08	8	0.000	2.15	8	0.000	2.03	8	0.000	0.915

Sig.* - Significance obtained from t-tests.

Interestingly, the ANOVA results indicated consensus of the three groups on the degree of importance (or relative importance) of all the features, despite their diverse background, and minor differences in rankings of the features. Such agreement is indicative of a common understanding on the suitability of the features, which can contribute to effective adoption of sustainable active design features in Brunei. By prioritizing and recognizing various active features, professionals are likely to collaborate and effect meaningful changes in practicing sustainable design features in buildings, which may lead to identifying underlying challenges and find suitable solutions to benefit the environment and economy.

4. CONCLUSIONS

Adopting passive design strategies in buildings can considerably lower energy consumption and CO_2 emission. However, passive strategies rely on the sun and wind, which are different in various countries and climate zones, as well as vary during different times of the day, month and year. Therefore, passive strategies need to be complemented with suitable active strategies, to ensure the comfort and well-being of occupants, especially in hot-humid countries with considerable fluctuation of wind, and heat and light from the sun. As such, this study identified seven suitable active design features for buildings. These are primarily suitable for Brunei, but may also be suitable for other hot-humid countries, depending on their level of awareness, knowledge and available rules and regulations. The only 'not suitable' feature is 'operable louvers' (A8), which may be suitable elsewhere. Brunei respondents clearly preferred three active features that are run by externally supplied energy, so they are not sustainable. The more sustainable active features are less preferred, probably due to the lower energy prices locally. Such preferences may also be indicative of lack of awareness and knowledge, as well as limited access to information, and insufficient initiatives on relevant education and training. With slight differences by different groups, the respondents seem to have consistently expressed their opinions. A suitable policy, along with supportive rules and regulations, and their inclusion in the 'building codes', may lead the industry towards practicing sustainable active design features, to supplement passive design features, all leading to a sustainable built environment. These outcomes are to be collated with the other segments of the overall study, which will target to develop a framework for adopting sustainable design features in buildings in hot-humid countries.

ACKNOWLEDGEMENTS

This work was supported by the scholarships for postgraduate studies of the Ministry of Education, Brunei Darussalam.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTION

M.M. Rahman (Conceptualization, Methodology, Formal analysis, Writing – orginal draft, Supervision)

N.A.H. Juffle (Investigation, Data collection, Data analysis, Data curation, Funding acquisition, Project administration)

R.A. Asli (Supervision, Writing – review and editing)

AVAILABILITY OF DATA AND MATERIALS

The data supporting this study's findings are available on request from the corresponding author

ETHICS STATEMENT

The study included no human or animal subjects, but data were collected from anonymous construction industry participants/practitioners. Ethical declaration was approved by the Civil Engineering Programme Area, Universiti Teknologi Brunei.

REFERENCES

[1] X. Cao, X. Dai, and J. Liu, "Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade," *Energy and Buildings*, vol. 128, pp. 198–213, 2016.

[2] United Nations Environment Programme, "2019 Global Status Report for Buildings and Construction," 2019. Available: https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019

[3] United Nations Environment Programme, "2022 Global Status Report for Buildings and Construction," 2022. Available: https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

[4] A. Atmaca and N. Atmaca, "Life cycle energy (LCEA) and carbon dioxide emissions ($LCCO_2A$) assessment of two residential buildings in Gaziantep, Turkey," *Energy and Buildings*, vol. 102, pp. 417–431, 2015.

[5] A. M. Fattah, J. Aminata, I. Susilowati, and A. Pujiyono, "Causality Analysis: Economic growth, economic openness, energy consumption, and carbon dioxide emission Indonesia," *Media Ekonomi dan Manajemen*, vol. 36, no. 2, pp. 124-134, 2021.

[6] N. A. H. Juffle and M. M. Rahman, "An overview of motivators and challenges of passive design strategies," *IOP Conference Series: Earth and Environmental Science*, vol. 1195, no. 1, p. 012039, 2023.

[7] M. Saridaki and K. Haugbølle, "Towards sustainable design: Integrating data from operation of buildings in design practices," *IOP Conference Series: Earth and Environmental Science*, vol. 588, no. 5, p. 052051, 2020

[8] S. Kubba, "Components of Sustainable Design and Construction," Chapter 2, *Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes, 2nd edn., Elsevier BH*, pp. 55-110, 2017.

[9] Y. Deng, Z Li, and J. M. Quigley, "Economic returns to energy-efficient investments in the housing market: Evidence from Singapore," *Regional Science and Urban Economics*, vol. 42, no. 3, pp. 506–515, 2012

[10] D. King, "Innovate Green Office: A new standard for sustainable buildings," *Proceedings of the Institution of Civil Engineers – Energy*, vol. 160, pp. 105–111, 2007.

[11] P. Cook and A. Sproul, "Towards low-energy retail warehouse building," *Architectural Science Review*, vol. 54, pp. 206–214. 2011.

[12] K. Raviraj, N. Gupta, and H. N. Shet, "Analysis of measures to improve energy performance of a commercial building by energy modelling," In *2016 Online International Conference on Green Engineering and Technologies (IC-GET)*, pp. 1–4, 2016.

[13] B. Daud, "Tropical sustainable architecture: Passive design strategies in green building," *Journal Online Jaringan Pengajian Seni Bina*, vol. 17, pp. 1-9, 2020.

[14] W. Khaliq and U. B. Mansoor, "Energy efficient design and sustainable buildings," In *2014 International Conference on Energy Systems and Policies (ICESP)*, pp. 1-8, 2014.

[15] M. Khoukhi, A. K. Shaaban, and O. Khatib, "Passive environmental design of an eco-house in the hot-humid climate of the Middle East: A qualitative approach," *Cogent Engineering*, vol. 7, no. 1, p. 1837410, 2020.

[16] T. Kubota, T. Takahashi, A. R. Trihamdani, H. Mori, and T. Asawa. "Development of a wind catcher for high-rise apartments in the hot-humid climate of Indonesia," *IOP Conference Series: Earth and Environmental Science*, vol. 1007, no. 1, p. 012008, 2022.

[17] T. Sikram, M. Ichinose, and R. Sasaki, "Assessment of thermal comfort and building-related symptoms in air-conditioned offices in tropical regions: A case study in Singapore and Thailand," *Frontiers in Built Environment*, vol. 6, p. 567787, 2020.

[18] C. Mitterer, H. M. Künzel, S. Herkel, and A. Holm, "Optimizing energy efficiency and occupant comfort with climate specific design of the building," *Frontiers of Architectural Research*, vol. 1, no. 3, pp. 229–235, 2012.

[19] Z. Wang, R. de Dear, M. Luo, B. Lin, Y. He, A. Ghahramani, and Y. Zhu, "Individual difference in thermal comfort: A literature review," *Building and Environment*, vol. 138, pp. 181–193, 2018.

[20] A. Katili, R. Boukhanouf, and R. Wilson, "Space cooling in buildings in hot and humid climates - A review of the effect of humidity on the applicability of existing cooling techniques," In *14th International Conference on Sustainable Energy Technologies*, vol. 3, p. 90. 2015.

[21] N. Murtagh, A. Roberts, and R. Hind, "The relationship between motivations of architectural designers and environmentally sustainable construction design," *Construction Management and Economics*, vol. 34, pp. 61–75, 2016.

[22] F. Shi, S Wang, J. Huang, and X. Hong, "Design strategies and energy performance of a net-zero energy house based on natural philosophy," *Journal of Asian Architecture and Building Engineering*, vol. 19, no. 1, pp. 1-15. 2019.

[23] M. Suhaimi, N. Ramli, M. Hamid, A. Kassim, and S. Munaff, "Active and passive strategies to improve energy efficiency for healthcare building," In *AIP Conference Proceedings*, vol. 2233, no. 1, p. 050015, 2020.

[24] M. Tavakol and R, Dennick, "Making sense of Cronbach's alpha," *International Journal of Medical Education*, vol. 2, pp. 53–55, 2011.

[25] D. Wulandari, S. Sutrisno, and M. B. Nirwana, "Mardia's skewness and kurtosis for assessing normality assumption in multivariate regression," *Enthusiastic International Journal of Applied Statistics and Data Science*, vol. no. 1, pp. 1–6, 2021.

[26] N. H. Julayhe and M. M. Rahman, "Greening existing buildings for energy efficiency: A review," *International Journal on Emerging Technologies*, vol. 11, no. 5, pp. 366–380, 2020.

[27] M. Rawat and R. N. Singh, "A study on the comparative review of cool roof thermal performance in various regions," *Energy and Built Environment*, vol. 3, pp. 327–347, 2022.

[28] A. M. Ahmed, W. Sayed, A. Asran, and I. Nosier "Identifying barriers to the implementation and development of sustainable construction," *International Journal of Construction Management*, vol. 23, pp. 1277–1288, 2023.