

Assessing the Sustainability of Solar Energy Utilization in Students' Hostel in Nigeria

Odugboye E.O & Imafidon M.O.

¹Department of Architecture, Faculty of Environmental Sciences,
University of Benin, emmanuel.odugboye@uniben.edu

²Department of Quantity Surveying, Faculty of Environmental Sciences,
University of Benin

monday.imafidon@uniben.edu

Abstract

This study aims to assess the impact of acceptance of solar energy technology on building energy utilization among off-campus students' hostel in Nigeria. The study used quantitative methods based on the premises of the Extended Unified Theory of Acceptance and Use of Technology (EUTAUT). Partial Least Square Structural Equation Model was adopted to measure 19 critical drivers of solar energy technology's impact on energy utilization among 225 purpose-built off-campus students' hostel in public universities in Nigeria. The study found that solar energy systems contributed to a 38% reduction in hydroenergy consumption in the total floor areas and a 100% increase in consumption in the total building surrounding (exterior) of students' hostel. These were mainly driven by the behavioural intentions of students' hostel owners toward the acceptance of solar energy technology as alternative to hydro energy. There have been limited studies on energy management in students' hostel. However, this study determined critical areas of students' hostel that require a high/low energy supply using solar energy technology.

Keywords: Hostel, Energy, solar, equation, model

Introduction

Energy consumption continues to be a significant challenge across all sectors of the global economy as the human population increases exponentially. Families and communities are expanding, hence increasing the energy demand. International policy efforts catalogued by SDG4, which calls for inclusive education and promotes lifelong learning opportunities for all, have recorded substantial changes in students' enrolment, especially in developing countries (UNESCO, 2022). Statistics in Nigeria, for instance, shows that students' enrolment at the tertiary level has increased to (11.81%) in 2018 (UNESCO, 2022). This high enrollment has put immense pressure on authorities to supply adequate hostel for students', hence the increasing development of off-campus hostel (Appau *et al.* 2022). Central to this development, off-campus students' hostel has been subjected too much pressure for space and energy (Avogo *et al.* 2022). Traditionally, students' access to energy is critical for improving their academic performance and social life (Elinwa *et al.* 2023). Many fundamental activities outside the

university classroom are met by energy, especially cooking, cooling, entertainment, and lighting in students' hostel.

In the developing world, more energy is derived from hydropower, which is not enough compared to coal, gas, and fossil in the developed world (Takase *et al.*, (2022). Renewable energy solutions such as solar energy have emerged as one of the options to safeguard energy vulnerability, climate change, environmental sustainability, and a healthy built environment in developing countries (Elinwa *et al.*, 2023).

Literature Review

Extended Unified Theory of Acceptance and Use of Technology (EUTAUT)

The emergence of energy technology in various sectors has become inevitable in producing the required results. However, investments in these technologies are innately expensive and dicey (Venkatesh *et al.* 2003). Based on that, scholars have propounded technological and psychological theories and models such as the Technology acceptance model, theory of planned behaviour, unified theory of acceptance and use of technology, and theory of reasoned action to facilitate technology improvements. Among these theories, the unified theory of acceptance and use of technology and the technology acceptance model have been used extensively (Venkatesh *et al.* 2003). The extended unified theory of acceptance and use of technology has recently emerged to improve the unified theory of acceptance and use of technology (Venkatesh *et al.* 2016). The premise of the theory is based on four main factors. These include performance expectancy, social influence, and facilitation condition and effort expectancy. These are directly determining factors that influence technology adoption. The extension of the theory to include hedonic value, environmental conditions, behavioural intention, attitude, and habits has been reported by researchers as indirect drivers of the use of energy technologies (Almrafee & Akaileh, 2023).

According to the theory, performance expectancy explains the expectations of using technologies and has been justified as the strongest predictor of technology use. Effort expectancy describes the personal reasons for adopting and using technology. Social influence, on the other hand, represents the perception of others' attitudes toward the use of technology and beliefs associated with the adaptation. The facilitation condition refers to the availability of technologies association infrastructure for its functioning. Hedonic value, also called motivational value, explains the cost and pleasure of using the technology. Habit describes the extent of belief in the proper functioning of technology. This is synonymous with behavioural intentions. Environmental concern represents the environmental performance expected from the use of technology.

Solar Adaptation in university campuses

The adaptation of renewable energy across university campuses is emerging. The sustainable university campus has been the call by many researchers (Geh *et al.*, 2022; Wang *et al.* 2021; Zomer *et al.*, 2020). Scholars have shown a positive relationship between solar energy adaptation and building performance on university campuses. According to Al-Ghussain *et al.* (2021), the adaptation of a sustainable university campus reduces energy costs and increases efficiency. Al-Ghussain *et al.* (2021) further indicated that increasing the use of renewable energy provides a safe and reliable energy supply on the university campus. Scholars have highlighted that the use of solar energy in university buildings reduces energy costs and improves building performance (Opoku *et al.*, 2020; Mansur *et al.* 2018; Hasapis *et al.* 2017). Others underscore that solar adaptation in university buildings supports climate change and sustainable development goals initiatives (Geh *et al.* 2022; Creutzig *et al.* 2017). Empirically, Muhammad and Habib (2023) assessed the adaptation of green campus initiatives among Pakistan Universities. Their study found that the adaptation and adherence to green initiatives among the Capital University of Science and Technology led to the eighth position in the Universitas Indonesia-GreenMetric World Ranking 2020. Mostafaeipour *et al.* (2021) assessed found solar energy adaption to be environmentally and economically justified when studying the impact of using solar energy in 10 locations in Canada. Roberto *et al.* (2019) also assessed the use of renewable energy on a university campus in Brazil and found that high improvement in knowledge among students' when solar energy was introduced to facilitate lighting on campus. Asif *et al.* (2019) also assessed the use of PV solar at King Fahd University of Petroleum and Minerals (KFUPM) using economic feasibility analysis. Their study found that PV solar was economically viable to ensure a sustainable energy supply on campus. Geh *et al.* (2023) assessed the drivers of the adaptation of solar technology in South Africa using the Delphi technique and found that universities adopt solar technology due to financial returns. Their study found that the sustainability of university campuses, reduction of greenhouse gases, and contribution to sustainable development goals were key motivations for solar energy adaptation.

Methodology

The study assesses the impact of solar energy technology acceptance on building energy utilization among off-campus students' hostel in Nigeria. The study used quantitative research approaches. This includes a detailed test of the Extended Unified Theory of Acceptance and the technological impact of solar energy on students' hostel energy utilization. The philosophical assumption of the study was based on the positivist standpoint. Positivists believe that quantitative data studies are more reliable than other research methods because they standardise systematic data instrument design processes and logical analysis sequences (Bonache, 2021). Based on the positivist view, a survey and multi-stage sampling approach were adopted in two phases. First, a list of off-campus purpose-built students' hostel data was

collected from the Dean of Students' Offices in 8 traditional public universities out of 13 in Nigeria. The eight selected universities are campuses where solar energy has primarily been utilized in the off-campus students' hostel market.

The second phase involved the selection of purpose-built students' hostel that uses solar energy as a backup to hydropower. In the second phase, 225 purpose-built students' hostel qualified for the survey. A list of survey questionnaires was sent to students between December 2022 and February 2023. The questionnaire was grouped into two parts. Part one described the socio-demographic data. The purpose was to determine the extent of experience of using solar energy, considering their ages, gender, education, and time of adopting solar energy in purpose-built students' hostel. Part two of the questions were structured to constitute the solar energy capacity adopted, the percentage of solar use in buildings' usable areas and surroundings, and the impact of adopting solar energy on building energy utilization.

The Structural Equation Model Setup

Structural equation modelling is a scientific model used to explain the direct, indirect, and total effects among interconnected indicators and variables of a quantitative study (Jeon et al. 2015). The study adopted the Partial Least Square Structural Equation Model (PLS-SEM) instead of the covariance-based structural equation model because of its fewer limitations regarding the data structure. The PLS-SEM allows the use of only one or two construct variables and further maximizes the explained variances of endogenic indicators of the study (see Figure 2). The PLS-SEM setup of the study involved the variable definition, model specification, parameter estimation, and model testing. The paths in the arrows define the hypothesis of the study. L1 (latent variable 1) describes the relationship between the observed and dependent variables. The latent variable (L2) also defines the building energy utilization. Observed indicators of the L1 are designated as Total Floor Area (TFA) and Total Building Surroundings (TBS)

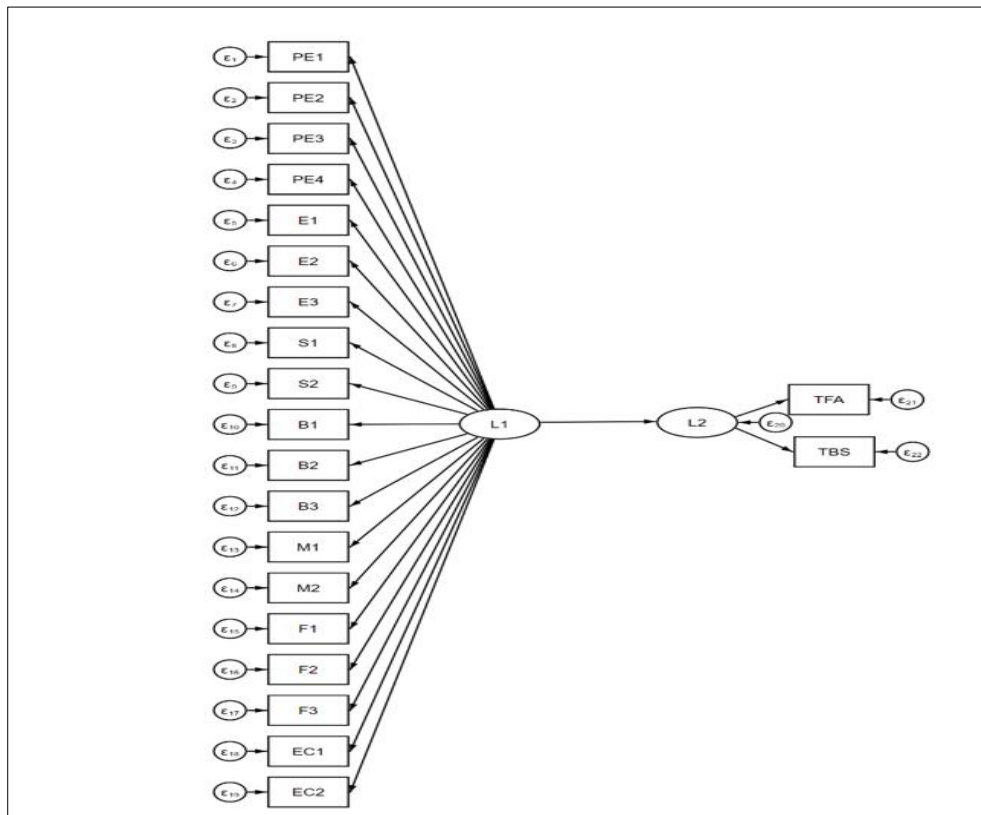


Figure 1: Structural model for assessing solar adaptation effects on energy utilization
 Source: Authors construct (2023)

Variable Definition

The variable definition involves seven dependent latent variables and 20 observed indicators. This was adopted from the extended theory of unified technology use, acceptance, and literature (see Table 1). These include performance efficiency, effort efficiency, behavioural intention, motivational value, facilitation condition, social influence, and environmental concern. These hypotheses seek to answer the impact of solar energy adaptation on students’ hostel energy utilization. Observed variables are indicators that drive the latent constructs (see Table 1). The indicators were measured on a 5-point Likert scale; 1-Strongly Disagree and 5-Strongly Agree. Table 1 explains the variable definition and mode of measurement.

Table 1 Drivers of solar energy adaptation in students’ hostel

Drivers	Impact	Dependent variable	Indicators	Drivers
---------	--------	--------------------	------------	---------

PE1	-----▶	PE	I would find the adaptation of solar energy systems in students' hostel operations.	Performance expectation
PE2	-----▶	PE	Solar energy systems would serve as a substitute for hydro and make energy purchases cost-effective.	Performance expectation
PE3	-----▶	PE	I think purchasing solar energy systems would create a more compatible environment.	Performance expectation
PE4	-----▶	PE	I think using solar energy systems would reduce energy instability in students' hostel.	Performance expectation
EE1	-----▶	EE	Solar energy systems are simple to install and understand	Effort expectancy
EE2	-----▶	EE	Solar energy systems are more straightforward to use than other renewable smart energy solutions in students' hostel.	Effort expectancy
EE3	-----▶	EE	Learning how solar energy systems are controlled in students' hostel for energy conservation is easy.	Effort expectancy
SI1	-----▶	SI	Other students' hostel thinks using solar energy systems as a backup energy supply makes sense.	Social influence
SI2	-----▶	SI	Energy solutions experts have advice for using smart energy systems in homes.	Social influence
BI1	-----▶	BI	I have always planned to use solar energy systems in the students' hostel	Behavioural intention
BI2	-----▶	BI	I intend to increase the capacity of solar energy systems in the students' hostel when I improve the facility.	Behavioural intention
BI3	-----▶	BI	I will adapt to solar energy solutions whenever I intend to create new students' hostel.	Behavioural intention
MI	-----▶	MI	Solar energy systems provide a cost-effective energy supply	Monitory value

M2	-----▶	MI	I think solar energy systems are reasonably priced in the market	Monitory value
FC1	-----▶	FC	The low electrical infrastructure allows for easy installation of the solar systems.	Facilitation condition
FC2	-----▶	FC	The availability of high-quality batteries in the solar system is sufficient to conserve energy in students' hostel.	Facilitation condition
FC3	-----▶	FC	I think the availability of PV pipes, meters, and inverters facilitates its installation.	Facilitation condition
EC1	-----▶	EC	I am concerned with the impact it has on health conditions	Environmental concern
EC2	-----▶	EC	I think the position/location of solar in the building may not impact students' habitation.	Environmental concern

Source: (Field survey, 2023)

Findings

Demographic Characteristics

Demographic characteristics of students' hostel owners show that males constituted the highest number of participants in the study. Concerning age, a large majority of the study participants were between the ages of 40 and 50, followed by ages between 30 and 40, respectively (see Table 2). The demographic characteristics also showed that most participants had higher educational levels (tertiary education). This reflects a high penetration of solar energy adaptation in students' hostel. Further, the study recorded a high utilization rate of solar energy systems in students' hostel between 3-5 years, representing (39%). On the other hand, only (4%) of students' hostel adopted solar energy systems in students' hostel over the past ten years. This implies that solar energy systems are steadily gaining adaptation in students' hostel.

Table 2 Demographic results of respondents

Description	Frequency	Percentage
Gender		
Male	207	92
Female	18	8
TOTAL	225	100
Age		

Less than 30	33	15
30-40	79	35
40-50	83	37
50-60	23	10
60+	7	3
TOTAL	225	100
Education level		
None	13	6
Basic	26	12
Secondary	48	21
Tertiary	138	61
TOTAL	225	100
Level of solar energy utilization		
Less than one year	10	4
1-3	42	19
3-5	88	39
5-7	67	30
7-9	10	4
More than ten years	8	4
TOTAL	225	100

Source: (Field survey, 2023)

Solar energy system utilization

The study assessed the solar energy capacity utilization in students' hostel in Nigeria. Data from annual meter readings showed that students' hostel utilizes solar energy systems with the highest capacity of 535Ws and 100Ws as the lowest (see Table 3). The increased utilization capacity was witnessed in the total usable areas of students' hostel. Functional areas of the students' hostel were defined as areas such as bedrooms, kitchens, study areas, lavatories, and utility areas. Total building surroundings such as balconies, corridors, and outside spaces recorded an annual average

Model Results

This section presents the model standard error of regression weight, weight of estimates, path coefficient, critical ratio, and significance level for a two-tailed regression weight of 0.05 (see Table 5). These measurements examine the convergent validity of the model. Convergent validity explains the extent of overlaps between the scales of measure in question and the indicators. Factor loads and path coefficients were used to indicate the correlation and weight of each hand. Estimating the drivers of performance expectancy, effort efficiency, social influence, facilitation condition, motivation value, behavioural intention, and

environmental concern of the use of solar energy systems on students’ hostel energy utilization, the model results in PE1, PE, P3, E2, E3, S1, B1, B2, B3, M2, F1, EC1, and EC2 were significant and influences energy utilization in students’ hostel (see table 5). PE4, E1, S2, MI1, F2, and F3 did not significantly affect energy utilization in students’ hostel (see table 5). Among the four performance efficiency indicators of solar energy use, the perception of solar energy systems as a substitute (PE2) to the national grid highly contributes to limited energy utilization in students’ hostel compared to (PE1) and (PE3) (see Table 5). Effort expectancy was also perceived to impact energy utilization in students’ hostel positively. The perception of acknowledging solar energy solutions as easy to use (E2) over other renewable energy solutions influenced students’ hostel energy utilization. Aside from this, the study recorded that the availability of solar batteries drives energy utilization at an acceptable rate compared to experts’ advice on renewable energy systems use capacity.

Even though reliance on expert advice (S2) as a source of solar use recorded a high estimate, it does not significantly influence energy utilization in students’ hostel. It can serve as a predictor of energy solutions when students’ hostel owners face challenges. Again, the motivational value attached to the adaptation to the use of solar energy recorded the highest estimates. Among the indicators, the cost of solar energy systems highly influences energy utilization in students’ hostel (M2). Even though the perception of the cost-effectiveness of solar energy systems was insignificant, it recorded a high estimate. This implies that the knowledge of the cost of solar energy systems does not necessarily motivate students’ hostel managers to purchase solar energy systems. Behavioural intentions towards the use of solar energy systems were all significant. Among the indicators, the perception of planning to use solar systems (B1) recorded the highest estimate. Second, the intention to use solar energy systems in future students’ hostel investments (B2). Third, the intention to increase the energy capacity (B2) recorded the least.

Table 3: Drivers of solar energy utilization

Indicators	Construct	Path coefficient	Standard error	Critical Ratio	Supported?
PE1	PE	0.010	0.097	28.92	Yes
PE2	PE	0.041	0.098	29.59	Yes
PE3	PE	0.013	0.959	21.23	Yes
PE4	PE	0.098	0.117	22.20	No
E1	EE	0.076	0.094	29.89	No
E2	EE	0.015	0.098	30.34	Yes
E3	EE	0.015	0.098	20.83	Yes
S1	SS	0.014	0.115	24.07	Yes
S2	SS	0.120	0.091	34.11	No
B1	BI	0.012	0.096	31.55	Yes
B2	BI	0.013	0.094	21.66	Yes
B3	BI	0.019	0.113	22.70	Yes
M1	MI	0.130	0.096	31.75	No

M2	MI	0.014	0.097	31.48	Yes
F1	FC	0.055	0.096	21.49	Yes
F2	FC	0.130	0.114	22.41	No
F3	FC	0.120	0.096	31.08	No
EC1	EC	0.011	0.115	22.27	Yes
EC2	EC	0.012	0.0933	32.21	Yes

Source: (Field survey, 2023)

Discussions of Findings

The study assessed the impact of drivers of solar energy technology adaptation on energy utilization among students' hostel in Nigeria. Using the partial least square structural equation model, the test of data validity showed that the Co-efficient of Determination (CD), Root Mean Square Error of approximation (RMSEA), P-close, Chi-square, Comparative fit index (CFI), and Tucker-Lewis index (TLI) fell within the acceptable levels of determination and indicates a model fit as described by Hu and Bentler (1999). From the model, 19 factors were segregated into seven constructs, representing the consolidated drivers of solar energy that impact energy utilization in students' hostel. Generally, according to the path coefficient, it was observed that solar energy has a high contribution to energy utilization and sustainable consumption in students' hostel. The model recorded a combined ($\beta=-0.002$), implying that the drivers reduce building use intensity by 0.29%. Aside from this, the model further showed a high reduction in solar energy utilization of generation capacity within the total floor areas of the building. The entire building's surroundings recorded a 100% reduction and sustainable energy utilisation. Given that the extended theory (Venkatesh et al., 2016) has extensively been applied in other sectors, performance expectancy, social influence, effort efficiency, behavioural intentions, facilitation conditions, environmental concern, and motivation value continue to be critical drivers of solar energy use impact on energy utilisation in this study. According to Roy and Mohapatra (2021), the extended theory posits performance expectancy as a high determinant of intentions to use solar. Many studies have supported this claim. Contrary to previous studies (Almrafee and Akaileh, 2023; Roy and Mohapatra, 2021), this study reported that performance expectancy was significant but did not positively impact building energy utilization in students' hostel. Hence, the study rejects the hypothesis that performance expectancy influences energy utilization. This result may be caused by the restricted use of solar energy in usable areas and building surroundings. Testing the complete adaptation of solar energy outside the national hydropower grid will enable students' hostel owners to determine the performance of solar energy. Critical performance indicators could assess its cost-effectiveness, usability, environmental compatibility, and energy sustainability in students' hostel.

Conclusion

The study assessed the impact of solar energy technology on students' hostel energy utilization in Nigeria. Using the PLS-SEM, the study identified that accepting solar energy technology is a backup to ensuring energy sustainability in students' hostel. The study further showed a reduction in energy consumption levels of generation capacity by 38% when using energy in the total floor areas of the building rather than the building surroundings. Critical acceptance drivers: effort expectancy, social influence, and behavioural intentions positively impacted solar energy adaptation's effect on building energy utilization. Among these, behavioural purposes for solar energy highly influenced energy utilization and sustainable consumption in students' hostel. Motivation value, facilitation condition, social influence, and environmental concern also significantly but moderately impacted energy utilization. These results serve as predictors of solar energy utilization. Performance expectancy did not provide any impact on building energy utilization. Conceptually, the study can conclude that the behavioural intentions of students' hostel owners drive students' hostel energy utilization and determine which part of the building requires high solar energy as a backup for sustainable consumption.

Theoretical and practical implication

The study hypothesized the impact of solar energy utilization in students' hostel using the extended unified theory of technology acceptance and use indicators. According to the theory, performance expectancy provides the most substantial impact on energy use. However, testing this claim in students' hostel did not prove positive. A correlation test between performance expectancy drivers and 19 other drivers showed a weak impact on building energy utilization.

Practically, given the high acceptance of behavioral intentions of solar as a critical contributor to building energy utilization in students' hostel, it will affect the energy supply in crisis regimes. Thus, students' hostel owners must bear high costs in reconnecting much of the energy load to floor areas. Aside from that, students' hostel owners must understand the performance expectancy of solar systems before purchase. This will enhance expectation efficiency and increase motivation for energy sustainability in students' hostel.

Limitations of the Study

The study is limited in two ways. First, the drivers of low reduction in solar energy utilization in total floor areas were missing in the study. This implies that further studies should examine the relationship between solar energy generation capacity and students' hostel consumption determinants. Second, the study could have used the 'with and without' scenarios

to provide a comprehensive picture that influences solar energy investment decisions in the Nigerian market.

References

- Almrafee, M. & Akaileh, M., 2023. Customers' purchase intention of renewable energy in Jordan: the case of solar panel systems using an extended theory of planned behavior (TPB). *International Journal of Energy Sector Management*, Vol. ahead-of-print No. ahead-of-print.
- Ali, S., Poulouva, P., Akbar, A., Javed, H. M. U., & Danish, M., 2020. Determining the influencing factors in the adoption of solar photovoltaic technology in Pakistan: A decomposed technology acceptance model approach. *Economies*, 8(4), 108.
- Appau, M.W., Attakora-Amaniampong, E. and Yakubu, I. (2022). Innovation diffusion effects on students' hostel investment in Ghana. *Property Management*. 41(2), 169-190
- Asif, M., Hassanain, M.A., Nahiduzzaman, K.M. & Sawalha, H. (2019), "Techno-economic assessment of application of solar PV in building sector: A case study from Saudi Arabia", *Smart and Sustainable Built Environment*, Vol. 8 No. 1, pp. 34-52. <https://doi.org/10.1108/SASBE-06-2018-0032>
- Avogo, F.A., Appau, M. W., & Attakora-Amaniampong, E. (2022). The effects of word-of-mouth and online review marketing strategies on students' satisfaction with their hostel selection during COVID-19 season, *Facilities*. 40(5/6),394-411.
- Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin* 107: 238- 246
- Bonache, J, 2021. The challenge of using a 'non-positivist' paradigm and getting through the peer-review process. *Human Resource Management Journal*, 31(1), 37-48.
- Creutzig, F., Agoston, P., Goldschmidt, J. C., Luderer, G., Nemet, G., & Pietzcker, R. C. (2017). The underestimated potential of solar energy to mitigate climate change. *Nature Energy*, 2(9), 1-9.
- Elinwa, U. K., Ogbeba, J. E., & Agboola, O. P. (2021). Cleaner energy in Nigeria residential hostel. *Results in Engineering*, 9, 100103.
- Geh, N., Emuze, F. & Das, D.K. (2022), "Barriers to the deployment of solar photovoltaic in public universities in South Africa: a Delphi study", *International Journal of Building*

- Pathology and Adaptation, Vol. ahead-of-print No. ahead-of-print.
<https://doi.org/10.1108/IJBPA-11-2021-0147>
- Geh, N., Emuze, F. & Das, D.K. (2023), "Drivers of solar photovoltaic deployment in South African public universities: a Delphi study", *Smart and Sustainable Built Environment*, Vol. 12 No. 2, pp. 407-434. <https://doi.org/10.1108/SASBE-08-2021-0140>
- Hasapis, D., Savvakis, N., Tsoutsos, T., Kalaitzakis, K., Psychis, S., & Nikolaidis, N. P. (2017). Design of large scale prosuming in Universities: The solar energy vision of the TUC campus. *Energy and Buildings*, 141, 39-55.
- Mansur, T. M. N. T., Baharudin, N. H., & Ali, R. (2018). A comparative study for different sizing of solar PV system under net energy metering scheme at university buildings. *Bulletin of Electrical Engineering and Informatics*, 7(3), 450-457.
- Mostafaeipour, A., Qolipour, M., Rezaei, M., Jahangiri, M., Goli, A. & Sedaghat, A. (2021), "A novel integrated approach for ranking solar energy location planning: a case study", *Journal of Engineering, Design and Technology*, Vol. 19 No. 3, pp. 698-720. <https://doi.org/10.1108/JEDT-04-2020-0123>
- Muhammad, L. & Habib, R. (2023), "Green Marketing Is Not a Choice but a Pre-Requisite for Z Generation: A Case of Green Campus Initiative in Capital University of Science & Technology, Pakistan", Quoquab, F. and Mohammad, J. (Ed.) *Sustainability and Social Marketing Issues in Asia*, Emerald Publishing Limited, Leeds, pp. 57-65. <https://doi.org/10.1108/978-1-80071-845-620231004>
- Opoku, R., Adjei, E. A., Ahadzie, D. K., & Agyarko, K. A. (2020). Energy efficiency, solar energy and cost saving opportunities in public tertiary institutions in developing countries: The case of KNUST, Ghana. *Alexandria Engineering Journal*, 59(1), 417-428.
- Roy, S. & Mohapatra, S, 2021. Problems of adoption of solar power and subsequent switching behavior: an exploration in India. *International Journal of Energy Sector Management*. 16(1), pp. 78-94. <https://doi.org/10.1108/IJESM-08-2020-0015>.
- Takase, M., Aboah, M., & Kipkoech, R, 2022. A review on renewable energy potentials and energy usage statistics in Ghana. *Fuel Communications*, 100065.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D, 2003. User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), pp.425-478.
- Venkatesh, V., Thong, J. Y., & Xu, X, 2016. Unified theory of acceptance and use of technology: A synthesis and the road ahead. *Journal of Association for Information Systems*, 17(5), pp. 328-376.

- Wang, P., Liu, Z., & Zhang, L. (2021). Sustainability of compact cities: A review of Inter-Building Effect on building energy and solar energy use. *Sustainable Cities and Society*, 72, 103035.
- Zomer, C., Custódio, I., Goulart, S., Mantelli, S., Martins, G., Campos, R., ... & Rüther, R. (2020). Energy balance and performance assessment of PV systems installed at a positive-energy building (PEB) solar energy research centre. *Solar Energy*, 212, 258-274.
- Zulu, S., Zulu, E. & Chabala, M, 2022. Factors influencing households' intention to adopt solar energy solutions in Zambia: insights from the theory of planned behaviour. *Smart and Sustainable Built Environment*. 11(4), pp. 951