

Full Length Research Paper

Knowledge and understanding of energy efficiency in air-conditioning: Exploring perceptions from the manufacturing sector in Ghana

Jones Lewis Arthur^{1*} and Josephine Fianu²

¹Department of General Agriculture, Sunyani Technical University, P. O. Box 206, Sunyani, Ghana.

²Department of Mechanical Engineering, Institute of Distance Learning, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Received 20 February, 2020; Accepted 7 May, 2020

The study investigated Energy Efficiency (EE) measures and practices from the perspectives of Ghana's manufacturing sector. A mixed methods approach that applied both qualitative and quantitative methodologies guided the study. The quantitative approach was relevant to establish statistical inferences and the qualitative methods used to provide further in-depth understanding to statistic(s) provided by the quantitative analysis. A total of 774 respondents (636- food processing Industry, 138- Cement Industry) provided the population for the study. A sample size of 260 informed the study. Various sampling frames including purposive, cluster and simple random were adopted to select respondents. The study concluded that knowledge on EE awareness and practices occurring at the departmental levels was mixed but clear on servicing and cleaning of air-conditioning since the manufacturing industries placed premium on regularity of servicing ACs in their places of work. Also, the findings identified that failure to clean the heating, ventilating and air-conditioning systems, failure to close doors and windows while ACs were on and avoidance of the use of efficient refrigerants and new ACs as key factors that negatively impacted EE for the manufacturing industries. The contribution of single speed ACs to energy efficiency was minimal compared to the other energy wasting activities associated with the use of air-conditioning.

Key words: Air-conditioning, energy, management, efficiency, wastage

INTRODUCTION

The contribution of the manufacturing sub-sector to national development cannot be overemphasized. Despite these contributions, the operations of manufacturing industries have over the years been challenged by inadequate and unreliable power supply rendering

them inefficient in their inability to meet the required target of productivity (Owusu, 2010; International Energy Agency, 2017). Ghana's commitment to industrial energy efficiency improvement dates back to 1987 when the government initiated an 'Initiated Energy Rationalization

*Corresponding author. E-mail: jonesarthur2002@yahoo.co.uk Tel: 0244597296.

Program' in an attempt to address energy supply deficiencies through boosting the industrial sector resilience (Worrell and Kenneli et al., 2013). In view of the trends of electricity tariff surges and unreliable electricity supply, the adoption of electrical Energy Efficiency (EE) measures with focus on air-conditioning systems as well as alternative energy source is a step in the right direction.

Air-conditioning remains a major part of energy usage within buildings without which, visibility and productivity will be greatly affected (Xu et al., 2017). However, the amount of electricity consumed by lighting must be balanced against the need for a well-lit environment to ensure productivity, well-being, safety and health of the people it serves (Loe, 2003). Among electrical appliances lighting fixtures, air-conditioners and refrigerators are the three major electricity-consuming devices in developing countries like Ghana. It is, therefore, most appropriate to promote energy efficiency measures on the usage of these appliances in order to suppress electricity consumption. The potential electricity consumption by cooling-only air conditioners would be reduced by 8% in Ghana through the proper enforcement of energy efficiency standards (Koizumi, 2007; Gyamfi et al., 2015; Kumi, 2017).

Studies in focal areas such as energy control systems in offices, lighting control technologies, barriers to and driving forces for industrial energy efficiency improvements in African industries, smart lighting energy system for energy saving, energy efficiency development in manufacturing industries and building design for energy saving in ventilation systems are examples of research related to cooling energy savings (Allouhi et al., 2015; Şahin et al., 2016; Ahmadi-Karvigh et al., 2018). Moreover, improving EE is embodied in several multilateral agreements and national policies, such as the Kyoto Protocol, United Nation Framework Convention for Climate Change (UNFCCC), National Energy Policy, with the sole purpose of promoting cost-effective measures that improve the efficiency with which energy is used and subsequently reduce the emissions of greenhouse gases (Finnerty et al., 2018). Although studies on EE have been extensively conducted, the current study sought to scope it down to the manufacturing industries in Ghana, in order to assess EE in air-conditioning systems and explore options for efficiency (Kemausuor et al., 2011; Kambule, 2014).

Energy efficiency is argued to improve cost, comfort and most especially, serve as a good investment (Cole et al., 2018; Johansson and Thollander, 2018). But accepting to go energy efficient is challenged by the high cost associated with energy efficiency improvements. Energy Efficiency (EE) which implies using less energy to perform the same task, that is elimination of waste (Gellings, 2009), has attracted lots of attention in the energy discourse because the subject contributes significantly to the reduction of greenhouse emissions and associated

mitigation of climate change (Laitner, 2015; Cole et al., 2018; Raj, 2018). Some literature have argued that the upfront investment costs associated with policies and programmes to increase EE are about twice the actual energy savings; however, there is more than three times savings over investment accruable over time as a result of a 'rebound' effect when demand for energy end uses increase as a result of greater efficiency (Fowlie et al., 2018). Embracing EE, therefore, needs the application of effective energy management policies and programmes including the use of better devices, control systems, and demand-response schemes (Calvillo and Villar, 2016). Various arguments have therefore emphasized the need to explore energy efficiency in air-conditioning for energy management since the contribution of these vectors to energy consumption in buildings is significant.

Today, air-conditioning (AC) equipment represents nearly \$100 billion (100 million-unit per year for the global market) and accounting for 4.5 exajoules (4.26 Quadrillion Btus) of site energy consumption per year (International Energy Agency, 2013). This trend makes up just over 4% of global building site-energy consumption (Cao et al., 2016; Goetzler et al., 2016). Meanwhile, the adoption of AC in developed countries increased rapidly in the 20th century with a greater adoption in developing countries taking place in the 21st century, especially in places of hot and humid climates with large and growing population, such as India, China, Brazil, and the middle eastern nations (Goetzler et al., 2016). A study of electricity demand for cooling buildings as carried out by Oh et al. (2016) showed that cooling of buildings accounted for 31+/-2% of the total energy consumption in Singapore. But, a high conservative scenario that is, integrating absorbent dehumidifier and evaporative cooler can result in electricity saving of 21,096 GWh until 2030. In an effort to understand issues relating to energy efficiency awareness in the use of air-conditioners in buildings, some studies have highlighted the mediating roles of the department of work of energy users.

Shanker et al.'s (2017) research that studied *202 managers working in Malaysian companies* identified innovative work behaviour as a key mediator for EE and organizational climate for innovation and organizational performance. In Ahmad (2015) and Maclean et al. (2018) submissions, it came out that there was a close relationship between Green Human Resource Management (GHRM) and the appreciation of green culture in an organization. This, therefore, placed premium on the key roles that one's department of work could play in EE practices. Key amongst these was the effect of a business strategy for significant organizations such as human resource departments on incorporating 'green' technology in the office climate as a way to achieve innovation and organizational performance. In an attempt to understand these issues including others, the study examined the following objectives:

Table 1. Questionnaire distribution.

Company Name	Staff population retrieved	Questionnaire distribution	Number of questionnaire	Response rate (%)
Nestle Ghana Ltd.	138	160	136	85
GHACEM Ltd	636	100	83	83
Total	774	260	219	-

1. Examine energy efficiency awareness in the use of air-conditioning from the scope of the mediating roles of Department of Works of workers in Ghana Cement (GHACEM) and Nestle Ghana Limited, Tema.
2. Determine whether general energy efficiency in the use of air-conditioning are applicable to energy efficiency and from the perspective of Department of Work of workers in GHACEM and Nestle Ghana Limited, Tema.

MATERIALS AND METHODS

The study applied a case study design rooted in the desire to use a detailed approach to study a phenomenon within a limited time and space (Owusu, 2010). This was meant to provide some understanding into energy awareness in the use of air-conditioning. It also assessed energy efficiency in the use of air-conditioning and also explored the possible mediating impacts of the department of work of employees.

Two manufacturing companies, that is, Ghana Cement Company Ltd (GHACEM) and Cocoa Processing Company, Tema were purposively selected as options for incorporating EE for improved access to energy for industries in the manufacturing sub-sector of Ghana. The choice of the selected industries were appropriate since as major energy consumers in Takoradi and Tema respectively, they had had to grapple with the frequent challenge of meeting the energy demands of their operations. In addition, these industries have incorporated various efforts in order to become more energy efficient. The choice of these industries is relevant to set the pace and serve as a learning curve for other similar companies who continued to face the challenges of meeting their energy targets.

The study covered a total population of 774 (636 from Cocoa Processing Company, Tema and 138 from GHACEM as shown in Table 1). Respondents were grouped under clusters of engineering and non-engineering whereas a simple random sampling (lottery) was used to select the respondents from each cluster. Thus, Krejcie and Morgan's (1970) framework was used for establishing sample size.

$$S = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

where S=Required Sample size, X =Z value (e.g. 1.96 for 95% confidence level), N =Population Size, P =Population proportion (expressed as decimal) (assumed to be 0.5 (50%)), and d=Degree of accuracy (5%), expressed as a proportion (0.05) and a margin of error.

The use of the formulae resulted in the selection of 100 and 160 as sample sizes for GHACEM and Cocoa Processing Company, Tema, respectively. Of the sample size of 260, 219 respondents actually responded and returned the questionnaires. Therefore, a response rate of 84.23% was achieved which was satisfactory.

Primary data was obtained in the form of energy bills, recorded

meter reading on lights and air-conditioners which were used to estimate energy consumption of air-conditioning, interviewing 4 informants (2 each from each company) and surveys through the administration of questionnaires. A 5-point Likert scale was used to design the questionnaire to elicit respondent's perceptions on set of statements (Bertram, 2007; Joshi et al., 2015).

Questionnaires were analysed using IBM Statistical Product and Service Solutions (SPSS) version 21 (Hejase and Hejase, 2013), using the research objectives as the main themes guiding the analysis. Findings were presented with the aid of correlation and significance tests to assess the levels of association and also test for significance for key variables of the research. The parametric test tools, including chi-square analysis and Analysis of Variance (ANOVA) were used to examine the mediating roles of department of work on the various energy efficiency management practices in air-conditioning for the manufacturing industries.

An interview guide was used to assess the perceptions of heads of the different departments (engineering and non-engineering), that formed the two main divisions in the two manufacturing companies. Face-to-face interviews covered heads of the engineering and non-engineering sections of the two manufacturing industries. Questions used for the interviews related to; energy management and energy efficiency awareness in the use of ACs. The outcomes of the interviews were used to provide further clarifications to the descriptive statistics generated from the quantitative data.

Further analysis of energy efficiency options available to the two manufacturing industries were undertaken with emphasis on PV system; PV array size estimation using the available sunlight at the site, total number of panels needed, inverter size, battery size, charge controller size; afterwards, financial analysis was carried out (Chel and Kaushik, 2011).

Load estimation

The total load as was estimated using the energy use (kWh) data of the industry

PV array size

This was calculated by considering the amount of useful sunshine available for the solar arrays on an average day in Tema in the greater Accra region as shown in Figure 1. The worst month irradiation or insolation was used to calculate the size of the photovoltaic (PV) panel using the equation:

$$\text{The energy required from PV modules} = 1.5 \times \text{Daily energy use} \quad (1)$$

Where '1.5' is the derating or fudge factor which accounts for the system efficiency.

$$\text{PV array size} = \frac{\text{Energy required from PV module}}{s - \text{hours per day}} \quad (2)$$

$$\text{Number of PV modules required} = \frac{\text{PV array size}}{\text{PV module rated output}} \quad (3)$$

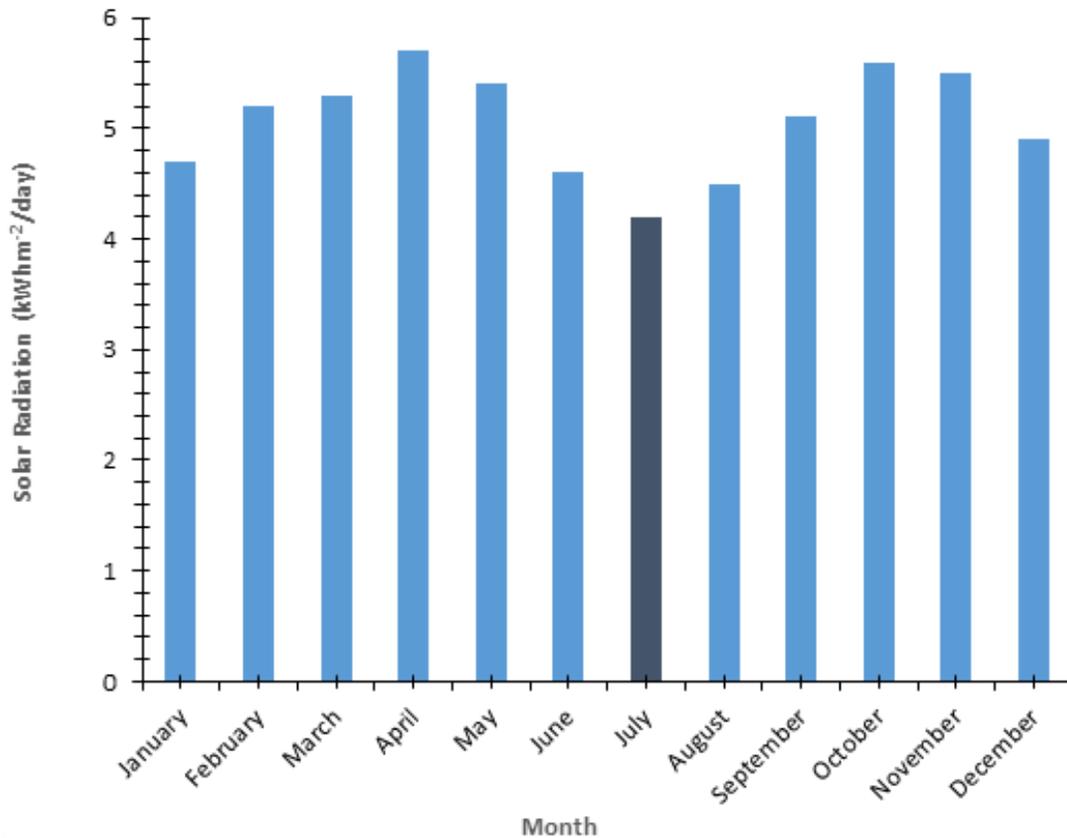


Figure 1. Monthly solar irradiation at Tema.

Battery sizing

The battery size was determined using the equation in order to determine how much storage the battery bank should provide

$$\text{battery size} = \frac{\text{daily energy use} \times \text{days of autonomy}}{\text{required voltage of battery bank}} \quad (4)$$

The system voltage chosen was 12 V and the days of autonomy was chosen as 5 days (Thus, the PV system should be capable of providing power continuously for 5 days without recharging).

Sustainability of renewable energy to the environment

To estimate the amount of CO₂ emissions mitigated due to the chosen renewable energy (solar PV system), 25 years lifetime of the PV system was used, and the CO₂ emission was estimated using the following equation

$$\text{Total CO}_2 \text{ mitigated} = \text{CO}_2 \text{ emission intensity factor} \times \text{Energy use per} \times \text{Lifetime of PV system (years)}$$

CO₂ emission intensity for electricity generation from a coal-based thermal power plant is approximately 0.98 kg of CO₂/kWh.

$$\begin{aligned} \text{Total CO}_2 \text{ emission} &= 0.98 \times 4046124 \times 25 \\ &= 99,130,038 \text{ kg} \\ &= 99 \text{ ktons} \end{aligned}$$

RESULTS

Demographic background of respondents

The respondents constituted 76.7% males and 23.3% females (Table 2). Employees who responded to questions registered a higher representation for non-engineering staff (56.8%) than engineering 43.2%. Technicians were 52.5%, followed by Supervisors (39.8%) and lastly Managers (7.6%). For the age grouping of respondents, it came out that 50% of the respondents were youthful from the 20-30 years bracket and 36.9% for those in the 31-40 years bracket. The remaining 40-51 years and 51-60 years groups' made up a marginal 13.1%.

Energy efficiency awareness in the use of air-conditioning

Respondents were assessed on EE awareness in the use of AC. The test of correlation and Analysis of Variance (ANOVA) statistics were adopted to assess perceptions on key variables.

Table 2. Demographics of respondents.

Demographics		Frequency	Percentage
Gender	Male	181	76.7
	Female	55	23.3
Department	Engineering	102	43.2
	Non-Engineering	134	56.8
Position	Manager	18	7.6
	Supervisor	94	39.8
	Technician	124	52.5
Age group (Years)	20-30	118	50.0
	31-40	87	36.9
	41-50	25	10.6
	51-60	6	2.5

ANOVA scores were analysed by the use of F values (variance between two means) and statistically significant values (to compare two means). These analyses were carried out in addition to percentages (descriptive frequencies), and means (comparison of averages).

Assessment of EE awareness in the use of air-conditioning was conducted to ascertain the regularity in servicing or cleaning air-conditioners, but from the perspective of the department of work of respondents. Generally, 80.7% of the respondents from engineering and 69.4% from non-engineering sections of the two organizations agreed that air-conditioning systems in their respective industries were regularly serviced. Informants added that in order to avert frequent complaint about the efficiency of ACs and also to ensure that the units are efficient in providing comfortable working conditions for employees, ACs were put on regular service charts. A test of correlation for whether the department of employees could mediate regularity of servicing/cleaning of air-conditioning systems registered significant scores ($X^2=12.299$, $p=0.015$).

On assessment of energy wastage activities in air-conditioning by department of work, it came out that 70.3-84.4% of the respondents agreed to all aspects of poor energy management activities as contributory factors to energy wastage at their places of work. Disagreements to the energy wastage activities ranged from the highest of 15.3% for use of very old air-conditioners to the lowest of 8% for leaving doors and windows open (Table 3). The output of the test was significant for organizations that upheld strong energy management practices as the majority of respondents were more informed about energy wastage activities in their organizations. Mean scores were highest for department of work under use of single speed air-conditioners (mean=2.25) and lowest for leaving doors and windows ajar while air-conditioners

were on (mean=1.83).

An examination of whether variations occur for energy wastage activities for the different departments of work showed disparities for all aspects of energy wastage, but each variable under energy wastage activities for engineering departments performed better than those of the non-engineering departments. Some key informants were of the view that such disparities were created by the absence of a uniform platform to coordinate energy wastage activities.

ANOVA test scores for department of work showed significance for all aspects of energy wastage activities in air-conditioning except, for use of single speed air-conditioners ($F=2.905$, $\text{sig}=0.095$) (Table 3). Respondents agreed that single speed air-conditioners were not regular units used in their organizations.

Respondents were further assessed on the perceptions as regards the application of basic EE practices applicable in the acquisition of air-conditioners by their departments of work (Table 4). It came out that not less than 62.3% for all variables of the respondents agreed to the application of basic energy efficiency activities for all aspects of basic EE practices. Key informants indicated that as part of incorporating sustainability into their lines of operation, the procurement units of the organizations were tasked to apply green procurement and other sustainability tenets in the procurement process. Mean scores were highest for purchasing new appliances only (mean=2.27) and lowest for checking the energy consumption of appliances before making a purchase (mean=0.962).

Mean scores for department of work were highest for engineering than non-engineering for all aspects of the application of basic EE activities (Table 4). As previously argued by key informants, risk management requirements are stricter in the engineering than non-engineering

Table 3. Energy wastage activities in air-conditioning by Department of Works.

Activity	Response to energy wastage activities					Mean	S.D	Department of Works (Mean)		ANOVA
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree			Engineering	Non-Engineering	
Not cleaning heating, ventilating and air-conditioning system	42.8	30.9	14.8	8.5	3.0	1.98	1.089	2.27	1.75	13.965 (0.000)
Leaving doors and windows ajar while air-conditioners are on	44.1	40.3	7.6	4.2	3.8	1.83	1.003	2.05	1.67	8.454 (0.000)
Not using very efficient refrigerant	30.5	39.8	17.4	9.3	3.0	2.14	1.050	2.47	1.90	18.678 (0.000)
Use of very old air-conditioners	39.8	33.9	11.0	8.9	6.4	2.08	1.198	2.42	1.82	15.446 (0.000)
Use of single speed air-conditioners	27.1	33.9	28.8	7.6	2.5	2.25	1.018	2.37	2.15	2.805 (0.095)

Table 4. Application of basic energy efficiency practices in acquiring air-conditioners by Department of Works.

Activity	Application of basic energy efficiency activities					Mean	S.D	Department of Works (Mean)		ANOVA
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree			Engineering	Non-Engineering	
Checking the energy consumption of appliances before making a purchase	40.3	39.8	13.1	4.2	2.5	1.89	0.962	2.04	1.78	4.401 (0.037)
Purchasing appliances with energy star label	37.7	36.0	19.5	4.2	2.5	1.98	0.987	2.01	1.96	0.177 (0.675)
Purchasing appliances with the highest number of energy stars	36.0	36.0	20.8	4.7	2.5	2.02	0.993	2.12	1.94	18.678 (1.852)
Purchasing new appliances only	32.2	30.1	25.4	8.9	3.4	2.21	1.094	2.27	2.16	0.588 (0.444)

engineering departments of the organizations, hence better EE practices for the former. Meanwhile, mean scores were highest (mean=2.27) for the activity “purchasing new appliances” and lowest (1.89) for “purchasing appliances with energy star labels” in the engineering department. For the non-engineering departments, mean score was highest for “purchasing new appliances only” and lowest (2.01) for “checking the energy consumption of appliances before making a purchase.

ANOVA test score was significant for Department of Works under the activity “checking the energy consumption of appliances before making a purchase” ($F=4.401$, $\text{sig}=0.037$).

DISCUSSION

Energy efficiency awareness in the use of air-conditioning

The study assessed perceptions on energy awareness in the use of air-conditioning, but from the perspective of departments of work of respondents. Discussions on the study were clear on disparities in EE awareness and practices occurring at the departmental levels and, therefore, a good prop for further discussion. For example, the findings of the study showed consistency with Ahmad's (2015) study on *Green human resource management: Policies and practices* that identified EE awareness disparities on departmental fronts of

green focused human resources management departments. On the regularity of servicing/cleaning air-conditioning system, all respondents were of the view that ACs at their places of work were regularly serviced since they attached greater importance to EE in their respective organizations. More so, a test of significance was positive for regularity of servicing ACs by department of work of respondents.

On the issue of energy wastage activities, majority of respondents (from both engineering and non-engineering) agreed to the following as activities that led to energy wastage; not cleaning heating, ventilating and air-conditioning system, leaving doors and windows open while ACs were

on and not using very efficient refrigerants, but using very old ACs. Although the study agreed to the use of single speed ACs as contributing to energy wastage, the margin was slim compared to the other variables. Many of these findings were consistent with Oh et al. (2016) in *Forecasting long-term electricity demand for cooling of Singapore's buildings incorporating an innovative air-conditioning technology* where they argued for the need to integrate absorbent dehumidifier and evaporative cooler as EE activities to reduce energy wastage in AC use. The variable, 'use of single speed air-conditioners' incidentally was the only variable that did not test significant to the mediating roles of the department of work. Generally, respondents opined that single speed ACs are not frequent features in their organizations.

Respondents in GHACEM and Nestle Ghana Ltd. agreed to the following as basic EE practices applied by their organizations in the course of acquiring ACs; checking the energy consumption of appliances before making purchases, purchasing appliances with energy star labels, purchasing appliances with the highest number of energy stars and purchasing new appliances. In these scores, the engineering sectors of the organizations performed better than the non-engineering sectors. Meanwhile, the department of work tested significant against assessing the energy consumption of appliances before making purchases.

Conclusions

The study investigated knowledge and understanding of energy management and efficiency awareness and practices in the use of ACs from the perspective of the manufacturing industrial sector of Ghana. The study results also covered an exploration of perceptions on what constitutes energy wastage in the use of ACs at the manufacturing sector.

Perceptions regarding knowledge on EE awareness and practices occurring at the departmental levels were mixed but clear on servicing and cleaning of air-conditioning since the manufacturing industries placed higher premium on regularity of servicing ACs in their places of work.

On the issue of energy wastage associated with AC usage, it was quite clear that failure to clean heating, ventilating and air-conditioning systems, failure to close doors and windows while ACs were on and avoidance of the use of efficient refrigerants and new ACs were key factors that negatively impacted on EE for usage of ACs. The contribution of single speed ACs to energy was minimal compared to the other energy wasting activities associated with the use of air conditioners.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Ahmadi-Karvigh S, Ghahramani A, Becerik-Gerber B, Soibelman L (2018). Real-time activity recognition for energy efficiency in buildings. *Applied Energy* 211:146-160.
- Ahmad S (2015). Green human resource management: Policies and practices. *Cogent Business and Management* 2(1):1030817.
- Allouhi A, El Fouih Y, Kousksou T, Jamil A, Zeraoui Y, Mourad Y (2015). Energy consumption and efficiency in buildings: *current status and future trends*. *Journal of Cleaner Production* 109:118-130.
- Bertram D (2006) Likert Scales: CPSC 681—Topic Report. Poincare, 1-11. Available from: <http://poincare.matf.bg.ac.rs/~kristina/topic-danelikert.pdf> (Accessed 8 November 2011).
- Calvillo CF, Sánchez-Miralles A, Villar J (2016). Energy management and planning in smart cities. *Renewable and Sustainable Energy Reviews* 55:273-287.
- Cao X, Dai X, Liu J (2016). Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. *Energy and Buildings* 128:198-213.
- Chel A, Kaushik G (2011). Renewable energy for sustainable agriculture. *Agronomy for Sustainable Development* 31(1):91-118.
- Cole JC, McDonald JB, Wen X, Kramer RA (2018). Marketing energy efficiency: perceived benefits and barriers to home energy efficiency. *Energy Efficiency* 11(7):1811-1824.
- Finnerty N, Sterling R, Contreras S, Coakley D, Keane MM (2018). Defining corporate energy policy and strategy to achieve carbon emissions reduction targets via energy management in non-energy intensive multi-site manufacturing organizations. *Energy* 151:913-929.
- Fowle M, Greenstone M, Wolfram C (2018). Do energy efficiency investments deliver? Evidence from the weatherization assistance program. *The Quarterly Journal of Economics* 133(3):1597-1644.
- Gellings CW (2009). The smart grid: enabling energy efficiency and demand response. The Fairmont Press, Inc.
- Goetzler W, Guernsey M, Young J, Fuhrman J, Abdelaziz O (2016). The future of air conditioning for buildings. US Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Office.
- Gyamfi S, Modjinou M, Djordjevic S (2015). Improving electricity supply security in Ghana-The potential of renewable energy. *Renewable and Sustainable Energy Reviews* 43:1035-1045.
- Hejase AJ, Hejase HJ (2013). *Research Methods: A Practical Approach for Business Students* (2nd edition). Philadelphia, PA, Masadir Inc.
- International Energy Agency (2013). *Transition to Sustainable Buildings: Strategies and Opportunities to 2050*. OECD/IEA. Available and accessed on 07 August, 2019 at: https://www.iea.org/media/training/presentations/etw2014/publications/Sustainable_Buildings_2013.pdf
- International Energy Agency (2017). *Market Report Series: Energy Efficiency 2017*. P 135. www.iea.org.
- Johansson MT, Thollander P (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry—recommendations for successful in-house energy management. *Renewable and Sustainable Energy Reviews* 82:618-628.
- Joshi A, Kale S, Chandel S, Pal DK. (2015). Likert scale: Explored and explained. *British Journal of Applied Science and Technology* 7(4):396.
- Kambule N (2014). A survey on the state of energy efficiency adoption and related challenges amongst selected manufacturing SMMEs in the Booyens area of Johannesburg (Doctoral dissertation, University of Johannesburg).
- Kemausuor F, Obeng GY, Brew-Hammond A, Duker A (2011). A review of trends, policies and plans for increasing energy access in Ghana. *Renewable and Sustainable Energy Reviews* 15(9):5143-5154.
- Koizumi S (2007). *Energy Efficiency of air conditioners in developing countries and the role of CDM*. Paris: International Energy Agency.
- Krejcie RV, Morgan DW (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement* 30(3):607-610.
- Kumi EN (2017). *The Electricity Situation in Ghana: Challenges and Opportunities*. Center for Global Development.
- Laitner JAS (2015). *The energy efficiency benefits and the economic*

- imperative of ICT-enabled systems. In: *ICT Innovations for Sustainability*. Springer, Chem. pp. 37-48.
- Loe DL. (2003). Quantifying lighting energy efficiency: a discussion document. *Lighting Research and Technology* 35(4):319-326.
- Macleane R, Jagannathan S, Panth B (2018). Overview. In *Education and Skills for Inclusive Growth, Green Jobs and the Greening of Economies in Asia*. Springer, Singapore. pp. 1-18.
- Oh SJ, Ng KC, Thu K, Chun W, and Chua K JE (2016). Forecasting long-term electricity demand for cooling of Singapore's buildings incorporating an innovative air-conditioning technology. *Energy and Buildings* 127:183-193.
- Owusu A (2010). Towards a reliable and sustainable source of electricity for micro and small scale light industries in the Kumasi Metropolis (Doctoral dissertation).
- Raj KB. (2018). Smart Grid Technology for Smart Homes—Risks and Benefits. In: *ICRTEMMS Conference Proceedings 634(640):634-640*. Swarna Bharathi Institute of Science and Technology.
- Şahin M, Oğuz Y, Büyüktürk F (2016). ANN-based estimation of time-dependent energy loss in lighting systems. *Energy and Buildings* 116:455-467.
- Shanker R, Bhanugopan R, Van der Heijden BI, Farrell M (2017). Organizational climate for innovation and organizational performance: The mediating effect of innovative work behavior. *Journal of Vocational Behavior* 100:67-77.
- Worrell E, Kermeli K, Galitsky C (2013). *Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making an ENERGY STAR® Guide for Energy and Plant Managers*.
- Xu L, Pan Y, Yao Y, CAI D, Huang Z, Linder N (2017). Lighting energy efficiency in offices under different control strategies. *Energy and Buildings* 138:127-139.