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Energy Management in a Residential Building Casestudy: Tenement Residential Apartment in Somolu, Lagos, Nigeria.

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ABSTRACT

Energy is essential to all human activities. Energy is an integral part of modern life. Energy demand has been on the high rise over the years while energy Supply has been so limited.With energy demand increasing daily and limited supply of Energy, there is a need to monitor and reduce energy consumption in our home since majority of the industries in Nigeria depends on Generator for their day to day activities. Residences are the major Consumers of National Grid Electricity.The main Objective of these research was to audit the energy in residential building, thereby ensuring a reduction in the energy consumption cost of the building.

From analysis of the data collected, it was found that the main grid electricity was the most used source of energy and the most used aspect of energy was lighting. By using the 80-20% rule, energy consumption by lightning was considered which resulted that about 70% of the hours the light was on was not needed, 12 bulbs were changed from Incandescent light to compacts led bulbs which made the regular energy consumption of 550Kwh to be reduced to 450Kwh in November 2019, thereby reducing the cost of energy.

Keywords: Audit, Energy, Management, Residential,Electricity cost/bill.

1. INTRODUCTION

Energy is very important to all human activities and, if truth be told it's extremely important to social and economic development. Energy is the basis of the trendy industrial economy [1]. It provides services for lighting and water heating, cooking, ventilation, food production and storage, education, extraction, industrial production and transportation. No country has managed to develop much beyond a subsistence economy without ensuring at least minimum access to energy services for most of its population, Modern energy Services are a powerful drive for economic and social development[4] Throughout the world most especially in developed countries the energy resources available and their ability to pay enormously determine the way in which people live their lives. Energy is an integral part of today's modern life [5]. It has become the blood of our day to day life, but it is not free. It comes at a monetary price and at anenvironment cost too. It is very difficult to think about our modern life without energy.

Every human need energy at every point in time, we can't do without it, so for the fact that we can't do without it there is a need for us to manage, improve, optimize it in other not to run out of it. [7]The objective of the energy system is to provide energy services. Energy services are the desired and useful products, processes or indeed services that result from the use of energy, such as for lighting, provision of air condition indoor climate, refrigerator storage. [11] With rising fuel costs and the opening of electricity and gas markets to alternate suppliers, the need to monitor and reduce energy consumption is receiving greater attention than ever before. [1] The process of managing energy is no new. energy should be regarded as a business course like raw materials and labour [12]. Nigeria is in a terrible energy condition with 60-70% of its population living without regular access to electricity. Most of the rural homes are not connected to national grid. With this Nigerian industrial development and economic diversifications plans are severely constrained. [2] [6]

The inability to obtain data for policy and investment planning is a serious issue in Nigeria for example, Nigeria is the second highest number of people without electricity in 2016 estimated at about 74million which is 39% of it population has no access to electricity [10]. even those that have access to it have limited access majority of the population depends on generator which is the alternative for electrical energy for most people. Some part of Lagos state uses electricity without paying for it, due to the energy crises of the nation. Even among household with electricity connections tracking residential electricity consumption is often a problem due to challenge of unmetered household, residencies that consume electricity from the public utility but have faulty or no meters to record electricity consumption for billing purposes. Meters provide household electricity consumption data that's important for energy policy process and implementation.

Residential Buildings

A residential building is defined as a building which provides more than the floor area for dwelling purposes. Residential building provides sleeping accommodation with or without cooking or dinning or both facilities. There are different types of residential building which are individual houses or private dwellings, Lodging or rooming houses, dormitories, Apartments, Hotels. For this Research I will be limiting my research to a residential apartment. An apartment is a building which consists separate dwellings for different. An apartment will reside minimum of three or more families living independently of each other. Making buildings energy efficient has been on the agenda of many energy experts, construction industry players and stakeholders on the backdrop of high costs of energy as a result of inadequate and unreliable supply of energy. [14]. The building sector is the largest consumer of energy globally, consumes approximately 40% of total energy (UNEP 2009). In the last two decades' global energy consumption has grown dramatically by 49% and the current prediction shows a global annual increasing trend of averagely 2% in energy consumption [18]. In the building sector, residential buildings consume the largest portion, followed by the commercial buildings and then industrial buildings.

Residential Metering

There are various metering platforms [electricity billing system] for residents across the nation. The methods of managing energy are not properly used with these methods. For instance, where there is no electricity supply or power, electricity bills keep coming. There is a need for Nigeria power sector to rise to the adoption of technology for an effective and efficient energy management system in the nation [8]. Sometimes in 2016 the Ikeja Electric Distribution Company of Nigeria employed some temporary staffs to inspect the challenges of unmetered houses with access to electricity the inspection reviewed that some of the reasons theycannot have a stable electricity power supply, majority of the residential buildings are using electricity without paying for it and daily we blame the government, forgetting that we all have our individual role to play.

A number and category of people occupying tenement apartment in Nigeria are not aware the term energy management because they are not informed or some ignorance. The average residential buildings require a significant amount to run and remain comfortable. Humans because of our individual habits or behaviours, our individual habits lead to energy wastage. For instance, the kitchen lobby light may be on even when there is natural light i.e. sunlight the fans, Tv, air conditioner may be on when no one is making use of them. All these activities add up to energy wastage which lead to increase of electricity bills. With the increase in electric power supply bills, some residents have resulted in illegal means of reducing power consumption by illegal tapping of power from the electric poles or feeders directly thus, short circuit the system. The illegal approaches are risky and can lead to loss of life. The residential energy management study of a tenement apartment in Somolu are of Lagos state is to audit the energy in that building inorder to reduce their energy consumption cost.

2. RESEARCH METHODOLOGY

The study investigated and described and compared 12 rooms in a residential building in Shomolu area Lagos so as to find out if energy management practices have been adopted in the apartments and the impact the practices have on the energy consumption or usage of the buildings [9]. The research approach adopted in this study was quantitativeresearch. Quantitative approach to research involves the utilization and analysis of numerical data using specific statistical techniques to answer like who, how much, what, where, when, how many, and how. It's also describes the methods of explaining an issue or phenomenon through gathering data in numerical form [19] [8]. The research methods or techniques adopted in this research are surveys, observations, questionnaires for both primary and secondary data collections. The study hugely adopts the questionnaire as the primary method of data collection with the general assumption that all the respondents to whom the questionnaire was administered to were of sound

mind, literate and understand their unique and important part they play in the success of the research though their responses are subjective.

Area of Study

The energy consumption of a building can be influenced by a multitude of parameter, such as Climate condition, The structure of the building and period of construction of the building, the level of employement and the behaviour of the oocupants. This provides an opportunity to describe the characteristics and issues related to the topic under investigation for a better understanding of the subject matter.
Anuoluwapo street is located in the west of Shomolu with the zip code of 101212. It is about 357meters long.

N0,4 Anuoluwapo street Shomolu is a tenement house commonly called "Face me I slap you", with about 24 rooms and 3 shops. About 86 occupants in the building. It is a storey building in which on the ground floor there is no regular habit of paying electicity bills, so my study will be limited to the 12rooms on the 1st floor with about 33 occupants. From observation, consumption rate of each occupants is due to different families owning different appliances with different power rating. This apartment is of the class A energy tariff of the Ikeja Electric Distribution of Nigeria.

Fig.1: No 4 Anuoluwapo Street Shomolu Lagos Nigeria.

Primary Data

The primary data for this project was gathered through questionnaires administered to the building occupants. The occupant's area parents and their children, young bachelors, and occupants of the shop. Observation and interviews were also used as another source of primary data through five reconnaissance visits undertaken to familiarize oneself with the study area and focus. The questionnaires were given to respondents at one visit and collected at a subsequent visit so as to give the respondents adequate time to answer the questions at their free time due to the fact that most of the respondents were not always around.

Secondary Data

Relevant books published and unpublished research projects, thesis, energy journal, and internet sources formed secondary data. The advantage of secondary data is it has a pre-established degree of validity and reliability, which requires no re-examination by a researcher who is re-using the data. Therefore, the secondary data analysis spared and saved a considerable amount of time which could be unrealistic for any individual to collect on their own[15].

Data Collection

The most fundamental and key source of data collection was an observation checklist that was used in obtaining the first-hand information to know if the building occupants have any idea what energy management is and whether the energy management practices were part of the occupant's culture and its effect to their energy consumption. Therefore, the survey turned out to have been useful in observing various features that were relevant to the research.
The researcher intends to use the number of occupants occupying the buildings and the number of occupants in each room to be able to calculate and obtain the perfect sample for the whole energy consumption. The information was tabulated as below: -

Table 1:Equipment Average Power rating (source:www.daftlogic.com)

APPLIANCE	AVERAGE POWER RATINGS
Microwave	1.7KW
Refrigerator	40W
Freezer	4KW
Television	85W
Sound system	95W
Electric Kettle	1.3KW
Electric Iron	1KW
Cellphone and charger	15W
Desktop computer	10W
Laptop computer	100W
Washing Machine	500W
Water pumping Machine	500W
Hair dryer	1.8KW
Electric shaver	20W
DVD player	20W
Dstv decoder	20W
Shower booster	10KW
Clothes dryer	4KW
Coffee maker	1.1KW
Wine cooler	83W
Water dispenser	100W
Wall Fan	60W
Vacuum cleaner	900W
Tube light	22W
Bread toaster	1800W
Oven	2.15KW
Air conditioner	4KW
Printer	30KW
Home Internet Router	10W
LED light bulb	10W

Table 2: No 4, Anuoluwapo str, Somolu, Lagos state.

Rooms	Number of occupants	No of electrical appliance used
1	6	8
2	2	2
3	2	3
4	4	10
5	3	3
6	6	8
7	2	2
8	1	8
9	1	3
10	3	5
11	2	7
12	1	2
Total	**33**	**61**

Data Analysis

The data analysis requires several related operations such as establishment of categories, the application of these categories to raw data through tabulating and then drawing statistical inferences. [13] [19]

The data collected were analysed using summaries which included quantitative approach, meaning summary of statistics and Visual, meaning simple-to-understand graphs. For ease of understanding and interpretation by users the researcher opted for the use of simple tools of data presentation which included percentages, graphs, tables and charts.

3. RESULTS

This study investigates the impacts of energy management on energy consumption in Residential buildings. To accomplish this, the researcher carried out a study in a residential tenement apartment. The aim of the study was to establish the relationship that exists between energy management and the energy consumption in residential apartments. The data collected was closely analysed. A total of 20 Questionnaires were administered to occupants of 12 rooms in a tenement apartment. Data was analysed based on the collected data through the questionnaires and interview during the researcher's visits to the buildings, researcher's observation and other secondary data collected during the research period were taking into account. The occupants of No 4 Anuoluwapo Street Shomolu were quite responsive the, out of the 20 questionnaires given to the occupants of building I was able to analyse my data base on feedback from 12 questionnaires and this was a result of lack of correspondence from some respondents who were not present on the first and second collection of the questionnaires and as time was not on the researchers' side, therefore the data analysis and presentation was based on the returned questionnaires.

Sources of Energy

From the building, analysis of the sources of energy as answered by the occupants of the building depicted that amongst the two sources of energy, electricity and generator. The most used source is the main grid electricity. The main grid electricity is given daily for period of 6hours to 10hours daily, expect where is a fault with the Adurosakin feeder, which lead to blackout in the Area. [3] [17]. The generator is used by some of the occupants and not all the occupants due to financial constraints. For those that have the generator puts it on from the hours of 8pm to 11pm only and according to the respondents, the use of the generator is not frequent i.e. it is not always on a daily basis. The main grid electricity routine for the Area gotten from the words of the occupants is tabulated below: -

Table 3: Electricity supply schedule (source: Authors analysis)

6am- 9am	4pm-7pm	
12am-3am	9am-1pm	7pm-10pm
5am-9am		6pm-10pm
6am-9am	12pm-3pm	6pm-9pm
	12pm-7pm	

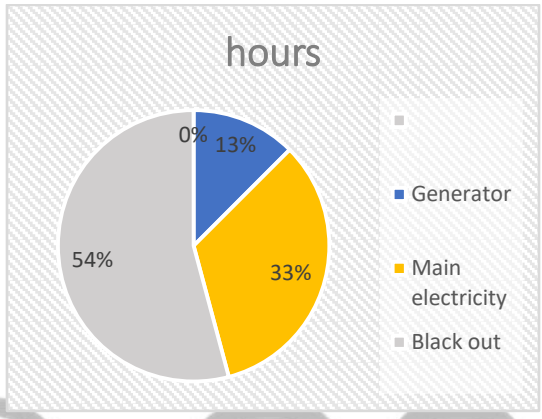

chart 1: electricity supply schedule (source: Authors analysis)

	Room 1		**Room 2**		**Room 3**		**Room 4**		**Room 5**		**Room 6**	
	PR (W)	WH	PR (W)	WH	PR (W)	WH	PR (W)	WH	PR (W)	WH	PR (W)	WH
Lighting	23	92	23	92	23	92	60	300	60	300	15	60
Tv	60	120		120			28	56			19	76
Fan	60	120			60	240	60	480	60	480	60	480
Cell phone	5	20					5	37.5			5	60
Decoder	15	30					15	30			15	60

Electric kettle	1500	750					----	-----			----	---
Cell phone charger	1	32					1	24			1	32
Refrigerator	------	-----					40	320				
Freezer					350	2800	----	-----				
Laptop							20	40			20	40
Lamp									5	10	5	80
Printer							40	40				
Hot plate									2000	3000		
DVD											19	38
Sound system												
Iron	1200	300					1500	750			1200	600

	Room 7		**Room 8**		**Room 9**		**Room 10**		**Room 11**		**Room 12**	
	PR (W)	WH	PR (W)	WH	PR (W)	WH	PR (W)	WH	PR (W)	WH	PR (WH)	W
Lighting	15	60	23	115	32	87	15	90	25	50	60	120
Tv			28	----					28	168		
Fan	60	240	60	180	60	240	60	480	60	480	60	480

Cell phone			5	30			5	45	5	10		
Decoder			15	----								
Electric kettle			1500	125								
Cell phone charger			1	16			1	24	1	16		
Refrigerator	40	320	40	320								
Freezer												
Laptop							50	100				
Lamp			5	15								
Printer												
Hot plate												
DVD												
Sound system			76	152			150	750	100	100		
Iron			1500	3000								

Table 4: Energy consumption at each rooms (Source: Authors Analysis)

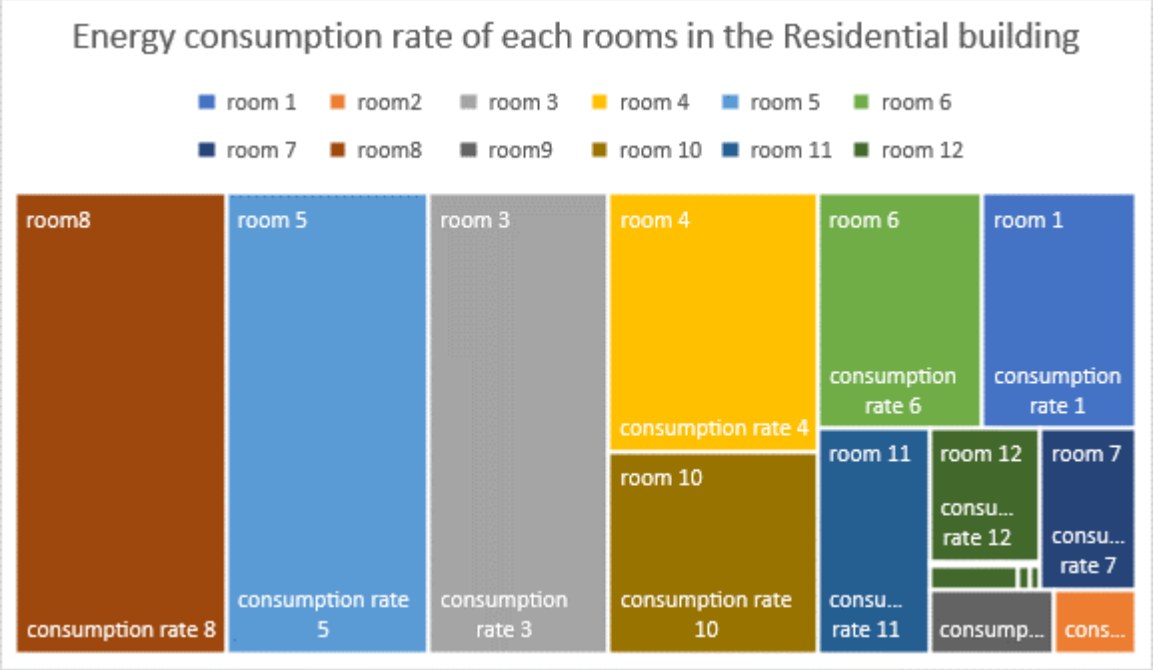

chart 2: Energy consumption rate of each rooms(*Source: Author's analysis)*

Daily Energy Consumptions

The occupants of the tenement residential building were not aware of the consumption of the various energy aspects in the building, the irony is, most of the building occupants use their desired energy fittings and the energy bills are shared equally amongst each other irrespective of the consumptionrate of each rooms, therefore the energy capacities and usage of the fittings (light fittings, , and telecommunication etc.) are not real much of their concern, some of the occupants pay less while some pay more. The daily energy usage by the 12rooms in the building is tabulated below, which compares the consumption of each room

Most used Energy aspect

From the building occupant's response, the energy aspect used in the building are artificial lighting, ventilation, refrigerator, electric cooker, iron, sound system, rechargeable lamp, cell phone, decoder, cell phone charger, laptop and printer. The chart below shows the most used energy aspect in the building.

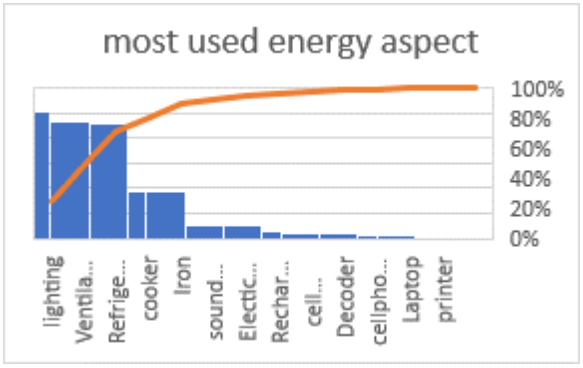

Chart 3: Most used energy aspects*source: Authors analysis*

From the chart3 above it shows that the most used energy aspects is lighting which ought to be the one of the least used because from the researcher's analysis artificial lighting should be on for only 6hrs daily from 6am to 8am, 6pm-10pm. Light out or bedtime is for 8hrs daily (10pm- 6am) and at this time the artificial lighting should be off. Natural lighting i.e. Sunlight is always available for 10hrs daily (8am-6pm). It was discovered that some of the occupants of the building don't switch off their lights expect at mid-night. Humans because of our individual habit or behaviour, our individual habits lead to energy loss. The kitchen, lobby light is always on even when there is natural light i.e. sunlight. It was also discovered that some parts of the building use incandescent light which is not economical and consumes a lot of energy. From pareto principle which is the 80/20 rule which states that 20% of our efforts yield 80% of our results. [19] It is the measure of where we can devote our efforts so as to increase our productivity and performance. Pareto said explore where your 20% lies and become more productive, by exploring where the 20% lies in this study it lies in lighting because most of the other energy aspects cannot be controlled, for instance in case of the Fan the hours of usage cannot be reduced since there is no other alternative for ventilation in the building and also fan cannot be changed to an energy saving fan do the cost of the fan in the market which is the same for other energy usage aspect in the tenement building expect from lighting

After Energy Auditing the researcher recommended to the occupants of No, 4 Anuoluwapo about changing the incandescent lights to compacts fluorescents lights. amongst other factors contributing to high consumption rate of energy, lighting was first considered.

The range of wattage of the compact's fluorescents light and the incandescent lights are tabulated table 5

Table 5: incandescent and compact fluorescent lights wattage range (source: Google)

INCANDESCENT LIGHTS	COMPACTS FLUORESCENTS LIGHT
40W	8-10W
60W	11-15W
75W	18-20W
100W	20-25W

The incandescent lights at the lobby, kitchen toilets and 3 rooms and bathroom were changed to compacts fluorescents light of 15W and energy consumption rate and energy cost reduced in the month of November 2019. In the month of September, October and November 2019 the average hours of electricity supply were 8hrs daily. In October and September, the energy consumption was 550Kwh. In November the energy consumption reduced to 450KWh due the change of the incandescent light to compacts fluorescent lights.

Units and Cost of Electricity Bills for a year

S/N	MONTH	KWH USED (KWH)	KWH COST (₦)
1	December 2018	727	15,862.77
2	January 2019	532	11,605.23
3	February	463.05	10094.49
4	March	694	15150.29
5	April	357	8,171.73
6	May	150	3270
7	June	0	0
8	July	651	14,191.80
9	August	500	10900
10	September	550	11,990
11	October	550	11,990
12	November	450	9,810

Table 6: Unit and cost of Electricity bill (source: Authors analysis)

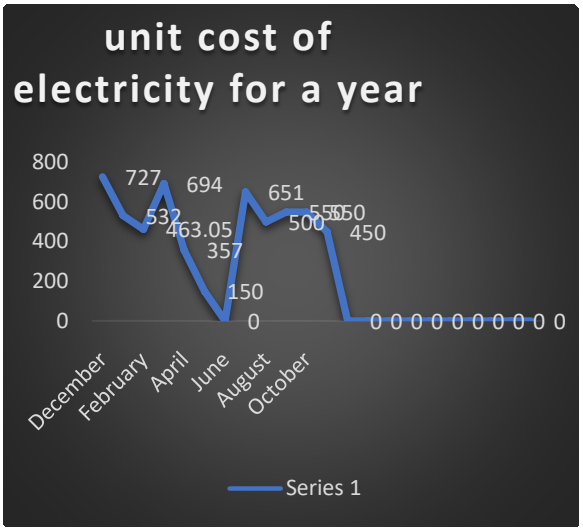

chart4 : unit and cost of electricity *Source: Author's* analysis

From the table 6 above the energy consumed in kWh in the month of September and October is 550kWh after the energy auditing and change of incandescent lights to compacts fluorescents lights the energy consumed in the November was reduced to 450kWh which caused their energy consumption usage to be reduced 100kWh and their energy consumption cost reduced 16.67% which helped the occupants of the building to save ₦2, 810 in the month of November.

Due to the limited access to electricity in Nigeria from the table and chart above it shows that there is constant or steady supply of electricity. Based on response from the respondent the area had no electricity supply for more than a month. The fluctuation in the energy consumption is has a result of the timing schedule of electricity from the Ikeja electric distribution company. The Ikeja electric distribution company's energy tariff rate is given below:

Energy Tariff Rate structure for residential tenement apartment in Nigeria

Energy cost = 21.8(₦/kWh)

Vat = 5% of energy consumption cost.

4. RECOMMENDATIONS AND CONCLUSION

The recommendations offered here are inferred and in line with the findings obtained from the study, therefore the researcher wishes to propose the following recommendations regarding the Impact of energy management in residential buildings.

Residential building, especially tenement apartments should incorporate energy management practice in the building and ensure that all the occupants of the building whether old or Young are involved in the day to day management of the energy they use. This is in accordance to the result of the research that proved that energy management helps in the reduction of energy consumption in residential buildings. This is in the status or background of ever rising price of energy in Nigeria.

The landlords or managers of the Residential building should ensure that there is an energy management awareness in the building to educate occupants of the building on how to manage the energy in terms of hours of using the artificial lighting which is the most used aspect of the energy consumption. And also, the monitoring and control of the energy consumption rate of each room in the building.

Furthermore, each rooms in the tenement apartment of the Residential building should be metered separately to ensure that the data collected on the energy consumption of each rooms can be tracked and also to ensure fairness

and equality because in the tenement building the occupants tend to pay the same about monthly for the energy consumed based on the fact that a sharing a single meter but from the data analysis the energy consumption for each rooms in the building are different but they end up sharing the electricity bill equally.

REFERENCE

[1] Kolokotsa D, Diakaki C, Grigoroudis E, Stavrakakis G, Kalaitzakis K. (2009). Decision support methodologies on the energy efficiency and energy management in buildings. Adv Build EnergyRes3:121–46. https://doi.org/10.3763/aber.2009.0305

[2] Sharma A, Tyagi VV, Chen CR, Buddhi D. (2009). Review on thermal energy storage with phase change materials and applications. Renew Sustain Energy Rev 13: 318–45. https://doi.org/10.1016/J.RSER

[3] Tyagi VV, Buddhi D. (2007). PCM thermal storage in buildings: A state of art. Renew Sustain Energy Rev 11: 1146–66. https://doi.org/10.1016/J.RSER.

[4] Chen, X. Z., C. B. Li, Y. Tang, and Q. G. Xiao. (2018). "An Internet of Things Based Energy Efficiency Monitoring and Management System for Machining Workshop." Journal of Cleaner Production 199: 957–968. doi:10.1016/j.jclepro.

[5] Fernandez, M., L. Li, and Z. Y. Sun. (2013). "'Just-for-peak' Buffer Inventory for Peak Electricity Demand Reduction of Manufacturing Systems." International Journal of Production Economics 146 (1): 178–184. doi: 10.1016/j.ijpe.

[6] Kaja, N. (2012). Review of built environment impacts on climate change, design strategies for reduction. Int. J. Civ. Struct. Environ. Infrastruct. Eng. Res. Dev. 2, 42–51

[7] Zhang, Y., He, C.-Q., Tang, B.-J. & Wei, Y.-M. (2015) China's energy consumption in the building sector: a life cycle approach. Energy Build. 94, 240–251.

[8] Jing, L. (2010) An empirical study of the relationship between inner Mongolia's energy and economic development. Sino Glob. Energy 15, 23–28.

[9] Kavousian, A., Rajagopal, R. & Fischer, M (2013). Determinants of residential electricity consumption: using smart meter data to examine the effect of climate, building characteristics, appliance stock, and occupants' behavior. Energy 55, 184–194

[10].BABATUNDE, A. and SHAUAIBU, I. (2009) 'The demand for Residential electricity in Nigeria' online source, available on www.africametrics.org/documents/conference 09

[11]. Birtles, A. B. & Grigg, P. (1997) Energy efficiency of buildings: simple appraisal method. Build. Serv. Eng. Res. Technol. 18, 109–114.

[12]. Yao, R., Yang, Y. & Li, B. (2012) A holistic method to assess building energy efficiency combining D-S theory and the evidential reasoning approach. Energy Policy 45, 277–285.

[13]. Nair, G., Gustavsson, L. & Mahapatra, K. (2010). Owners perception on the adoption of building envelope energy efficiency measures in Swedish detached houses. Appl. Energy 87, 2411–2419

[14]. Ma, M., Yan, R. & Cai, W. A (2017) STIRPAT model-based methodology for calculating energy savings in China's existing civil buildings from 2001 to 2015. Nat. Hazards 87, 1765–1781.

[15]. Chen, H., Lee, W. L. & Wang, X. (2015) Energy assessment of office buildings in China using China building energy codes and LEED 2.2. Energy Build. 86, 514–524.

[16]. Refahi, A. H. & Talkhabi, H. (2015) Investigating the effective factors on the reduction of energy consumption in residential buildings with green roofs. Renew. Energy 80, 595–603.

[17]. Zhifeng, X. & Yi, J. (2004). Energy consumption status and energy conservation potential analysis of large public buildings in Beijing. Heat. Vent. Air Cond. 34, 8–10

[18] Wayne, C.Turner (2001**).**Energy Management Handbook**(9th ed.)** united states ofAmerica**.** The Fairmont Press, Inc.

[19]. Copiello, S. & Gabrielli, L. (2017) Analysis of building energy consumption through panel data: the role played by the economic drivers. Energy Build. 145, 130–143.