Bima Journal of Science and Technology, Vol. 7 (4) Dec, 2023 ISSN: 2536-6041

DOI: 10.56892/bima.v7i4.534

Structural Equation Modeling of Residential Building Energy Consumption in Relation to Occupant Electrical Household Appliances Usage

[1]*Jibrin Hassan Sulaiman and [2]Abdulrahman Mohammed Adamu

1Department of Building Technology, School of Secondary Education (Technical) FCE(T), Gombe, Gombe State, Nigeria

[2]College of Education Billiri, Gombe State, Nigeria

Corresponding Author. hassansuleimanj@gmail.com

ABSTRACT

Despite the nonstop campaigns on global energy awareness and mitigation of Green House Gas (GHG) emissions in the last 50 years, there is more than 100% growth in CO2 emissions annually. If climate change measures are not taken, the global carbon emissions are predicted to rise to 64 billion tonnes CO2 by 2050. A survey was conducted to analyze how residential building inhabitants use different appliances focusing on energy consumption in Gombe State, Nigeria. The household head is tasked with giving information in response to the questionnaires. Residential owners' energy consumption was evaluated through the use of a drop-and-pick questionnaire. The survey included electricity energy used in air conditioning system, kitchen appliances, lighting appliances, refrigeration system, bathroom and laundry appliances, as well as other home appliances. The research work employed descriptive design, the study lead to the structured model development as the central focus of the study. A structured questionnaire consisting of 50 items was used as an instrument for data collection. The research population was Labour Housing Estate and Investment Quarters residents of Gombe. The information collected was analysed using descriptive and Confirmatory Factor Analysis. The results were analyzed using the path method tool of Amos 22 software and the correlation tool of Statistical Package for Social Sciences (SPSS). The research indicates that, there is a significant link between dwelling factors and the energy consumption of residential buildings.

Keywords: Residential Buildings, Energy Consumption, Greenhouse Gas Emission, Household Head

INTRODUCTION

The demand for housing is increasing all over the world due to growing populace and this leads to rise in the demand of energy use in buildings globally. The construction sector is the major contributor to energy consumption and because of the increasing demand of houses, Building Energy Consumption has recently become a major issue because of growing concern about carbon dioxide and greenhouse emissions (Ahmed Ali K, Ahmad MI, & Y., 2020). Heating, cooling and lighting appliances in buildings accounts for more than one third of the world primary energy demand (Hepbasli, 2012). Kyoto 1997 Agreement suggested that, energy consumption, pollution and emission that contribute to climate change and global warming should be reduced to minimum. Research proves that, forty percent (40%) of all energy is used in buildings (Ahmad & Zhang, 2020). This shows that, comfort provision on buildings has a major bearing on carbon dioxide emissions and energy consumption. Research conducted on buildings in respect to energy savings prove to be uncertain and ineffective because of the behaviors of occupants. Research conducted shows that most of the organizations have mainly concentrated on the managerial policy making with less emphasis on the occupants

DOI: 10.56892/bima.v7i4.534

behavior towards energy efficiency (Ahmad & Zhang, 2020).

Problem Statement

The major component that contributes to climate change which is generating a massive 50% of total Green House Gas discharges is construction activities as a result of urban development (Churkina, 2016). The construction industry is established and is quite inspiring in its role of providing residential building and structural development. However, the industry is faced with a series of challenges, particularly its contribution to carbon emission. The industry is responsible for an environmental threat in terms of natural resource consumption and is emitting million tons of carbon annually (Masoud Norouzi, Marta Chàfer, Luisa F. Cabeza, Laureano Jiménez, & Boer, 2021). Another weak point of the industry is its failure to blend the construction production process and the design process. The effort achieved by the Industrialized Countries of the 1970s and 1980s (Hong Kong, South Korea, Singapore and Taiwan) towards energy efficiency is as a result of meeting the consumer's demands (Zaid, Myeda, Mahyuddin, & Sulaiman, 2015). This approach is missing in the Nigerian construction industry. This study found this problem as a matter that needs proper investigation and possible solution. The amount of energy used per household varies widely depending on the standard of living of the country, climate, and other condition. The concept of Building Energy Consumption is very wide and complex. Energy is consumed in five different stages of building activities as follows: *Embedded or Embodied Energy* used in the production of building materials. *Gray Energy* used in transporting materials from production to the construction site. *Induced Energy* used in the construction of the building. *Operational Energy* used in the building throughout its lifespan and *Demolishing Energy* used in the demolition of the building after its lifespan or when the need arises. Because of the complexity of Building Energy, (cradle to grave) this research focus is on operational energy of residential buildings.

In an attempt to provide a better solution to the above problem, this study focus is on building energy consumption in relation to socio-economic, dwelling and climate factors. From the previous studies, socio-economic, dwelling and climate are the major attributes to residential energy consumption. There is numerous literature describing the influence of socio-economic on building energy consumption (Elnakat & Gomez, 2015; Frederiks, Stenner, & Hobman, 2015) In addition, some researchers focus on Dwelling Factors (Ramírez-Villegas, Eriksson, & Olofsson, 2016) while others have considered climate as a factor (Aldossary, Rezgui, & Kwan, 2014; Fumo, Mago, & Luck, 2010; L. Huang, Bohne, & Lohne, 2015; Mirrahimi et al., 2016). On the other hand, some researchers consider the influence of building energy consumption in residential buildings in a hybrid approach. These hybrid approaches are socio-economic and dwelling, dwelling and climate and socio-economic and climate (Figure 1). Socio-economic and dwelling factors influence on building energy consumption are studied by (Jones, Fuertes, & Lomas, 2015; Kelly, 2011; Longhi, 2015; McLoughlin, 2012). In addition, dwelling and climate were studied by (Chong, 2012; L. Huang et al., 2015; Kavousian, Rajagopal, & Fischer, 2013; Mirrahimi et al., 2016) and the last group consider socio-economic and climate (Blázquez, Boogen, & Filippini, 2013; Kavousian et al., 2013; Rehdanz, 2007; Štreimikienė, 2014). This study identified these 3 factors as the key influencing factor of energy consumption in the residential building. Residential building energy consumption can best understand when considering these 3 factors (Jones et al.,

DOI: 10.56892/bima.v7i4.534

2015). Figure 1 shows a picture of the previous literature in relation to socio-economic, dwelling and climate.

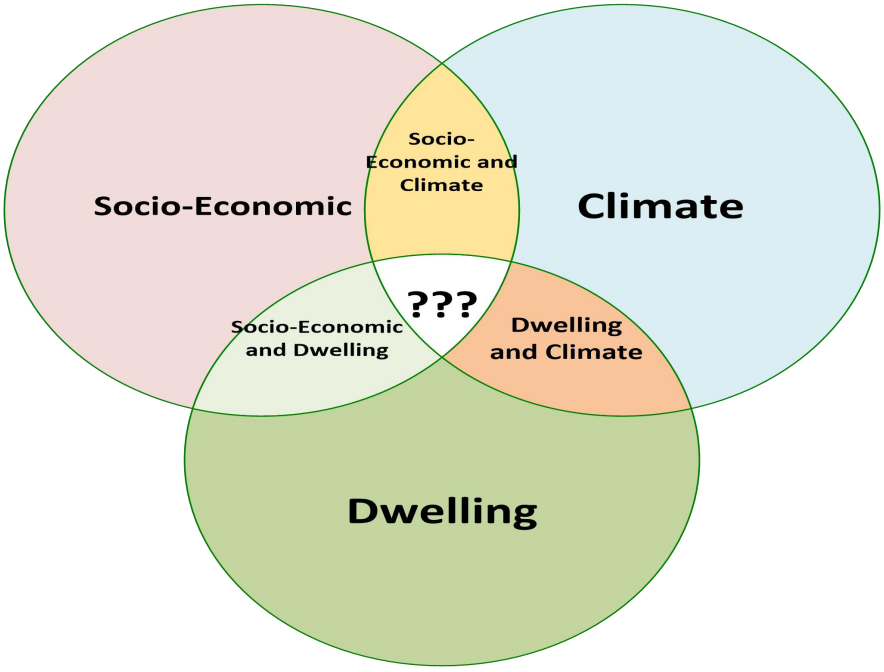

Figure 1: Diagram Showing the Research Gap Approach

The aim of the study is to identify a structural relationship of socio-economic, dwelling and climate factors for improving energy efficiency based on the understanding of the impacts on residential building energy consumption by the occupants. This can be achieved through identifying and analysing as well as establishing critical independent factors of energy consumption in residential buildings based on socioeconomic, dwelling and climate grouping.

Research Questions

The research question is poised to fulfill the objective in order to achieve the main aim of the research as stated below:

i. To what extent socio-economic, dwelling and climate factors influence consumption of electricity energy in a residential building?

Research Hypothesis

H_0 : Socio-Economic, Dwelling and Climate Factor has no significance and no direct effect on residential Building Energy Consumption. The null hypotheses was tested at 0.05 levels of significance.

Significance of the Research

This research is set to identify the structural relationship of socioeconomic, dwelling and climate factors in building energy consumption. The significance of this research could be seen in three aspects as;

i. Significance to the construction industry,

ii. Significance to residential building occupants and

iii. Significance to academic.

i. The need for this study becomes necessary due to the vibrant importance of construction industry's efforts attached to

DOI: 10.56892/bima.v7i4.534

building energy practice in the field of residential buildings. The fact that this discipline plays a vital role in reducing carbon emission and contributes to energy efficiency development in many countries across the globe. In line with this, it is hoped that, the findings from this study will provide a better solution to the construction industries in the choice of building design. It will also assist the construction industry professionals in the modification of the existing concept towards designing and reduction of carbon emission from the residential sector.

ii. It is believed that, without a significant increase in energy efficiency and significantly decrease of electricity demand from the domestic sector, it is merely impossible to lower carbon emission. Therefore, this research provides important information through empirical research. The most vital factors that donate to the general understanding of residential building occupants on energy consumption was provided. Findings of this research will give a better understanding of energy behaviour practice by residential building occupants.

iii. More fundamentally, the fact that building energy practice has been recognized as one of the strategies that can be used to reduce carbon emission. This research provides students, researchers, and scholars with literature related to the field of building energy. The findings from this study will add to the wealth of literature and serve as a reference information material to researchers and construction industries in the areas of building energy consumption. Government, Construction industries, estate developers and policy makers can find the outcome of this research useful in term of energy conservation.

Literature Review

The construction industry has been identified as a sector that provides social and economic infrastructure to the countries industrial growth and development. It is as well to provide basic amenities that include residential and commercial buildings and playgrounds. In addition, it provides recreation parks, stadiums, ports, railways, airports, dams, power generating plants, roads, highways, etc. In general, construction industry provides basic infrastructures, which is compulsory for any country's development. According to Myers (2013), the role of the construction industry to national economic development is significantly recognized by many kinds of literature. Even though, some literature maintains that the degree of its contribution is not always vibrant, it has been debated that for a particular country to have a meaningful and sustainable development, it must concentrate on advancing its construction industry. If the construction industry of a country is inefficient, it will be hard for such a country to realize a significant development (Olanrewaju & AbdulAziz 2015).

The below-listed points are considered as the major contributions of the construction industry to the nation’s development: It contributes positively to the nation's economy; GDP (Gross Domestic Product). It provides income generation and distribution. If well planned, it serves as a tool for achieving sustainable development. Contributes to Gross Fixed Capital Formation (GFCF). It significantly contributes to the informal sector. It generates employment.

And It utilizes outputs of many industries and equally provides outputs to many industries (Olanrewaju & AbdulAziz 2015).

Previous research in relation to the energy efficiency of buildings focuses more on Heating, Ventilation and Air Condition (HVAC) systems, lighting system and appliances as the major factors that attribute to the energy consumption in buildings. In addition, occupant behaviour and their

DOI: 10.56892/bima.v7i4.534

interaction with buildings and other energy consuming devices play a major role in the building energy consumption (Rusek R, Melendez Frigola J, & J., 2022). It is described that residential energy consumption is not only influenced by building characteristics, but also influenced by household characteristics, occupant behaviour, and efficiency of the service system (Xiaoxiao Xu, 2020). Residential energy use plays a vibrant role in contributing to GHG emission. Two major ways of reducing the energy consumption of the building were introduced by (Ahmed Ali, Ahmad, & Yusup, 2020). These are enhancing the energy efficiency of the devices, which will be used in substituting the existing types; an example is by replacing incandescent and fluorescent lights with LEDs (Light Emitted Diode) and the use of more energy efficient appliances in buildings. The presence of an individual in the buildings displays a compulsory situation for them to interact with it (Becerik-Gerber, Lucas, & Aryal, 2022). Every human being gives out heat and contributes to the pollution (water vapour, carbon dioxide, odours, etc.). Occupants of buildings similarly manipulate and interact with their environment and structures to obtain the maximum satisfaction they require. A good example is the heating and cooling of their environment in order to get better thermal comfort (Virote & Neves-Silva, 2012).Building energy consumption is very difficult to understand, unlike in other sectors of agriculture, commercial, transportation, and industry. This is because of self-interest, centralized ownership and capability in reducing energy consumption. The residential building sector is mostly an uncertain sector in term of energy consumption due to the following reasons:

- Undefined structure sizes and unspecified thermal materials usage
- Limited success in collection or distribution of energy-related data
- Occupant behavior (Tam, Almeida, & Le, 2018).

RESEARCH METHODOLOGY

The research considers descriptive design because it acquires a lot of information through description. The use of descriptive research design in behavioral sciences has been observed for a long period of time (Creswell, 2012; Stangor, 2011). In addition, a correlation design was employed as a procedure in quantitative research. This is a process in which investigators measure the degree of association or relation between two or more variables using the statistical procedure of correlation analysis. The research questionnaire was developed through literature review. The draft questionnaire developed undergone expert review and verification before the pilot survey. The questionnaire is divided into 2 sections. The first part (A) is the demographic information of the respondents. The second part (B) is of the research independent and dependent factors. The sources of literature review are journals, thesis, conference papers and internet sources. The population of this study refers to the household heads of 2 residential estates in Gombe metropolis (Investment Quarters and Labour Housing Estate). Simple random sampling, which refers to, the selection of a sample for study from a larger population was employed in this study. The quantitative parametric data obtained is analyzed using a tool of Confirmatory Factor Analysis (CFA), Exploratory Factor Analysis (EFA) technique, descriptive statistics as well as regression analysis process. This is achieved using an appropriate statistical package of SPSS software version 22 and AMOS statistical software version 22. A confidence level of 95% is considered while testing the hypothesis at significance level of 0.05 (Killeen, 2005).

The establishment of the factors was achieved through reviewed literature and

DOI: 10.56892/bima.v7i4.534

pilot questionnaire survey. The findings from this objective identify the research's independent and dependent factors. In general, the literature reveals that the trend of building energy consumption in residential building is on the increase. The findings from this literature study identified 31 independent related factors and 49 dependent related factors of building energy consumption in relation to residential buildings. The literature reviewed established fourteen (14) factors of socio-economic, eleven (11) of dwelling and six (6) of climate-related factors were analyzed using CFA and EFA through SPSS and AMOS statistical software packages. The 31 identified items of independent factors (Socio-economic, Dwelling, and Climate) are critically studied and only 17 items are considered fit for the study after CFA and EFA. The items considered fit for the study are seven (7) items on Socioeconomic, six (6) items on Dwelling and four (4) items on Climate-related factors. Figure 2 shows that, Dwelling Factor, which is defined by the orientation of the building (building positioning), building size and building type, has no significant neither direct effect on building energy consumption.

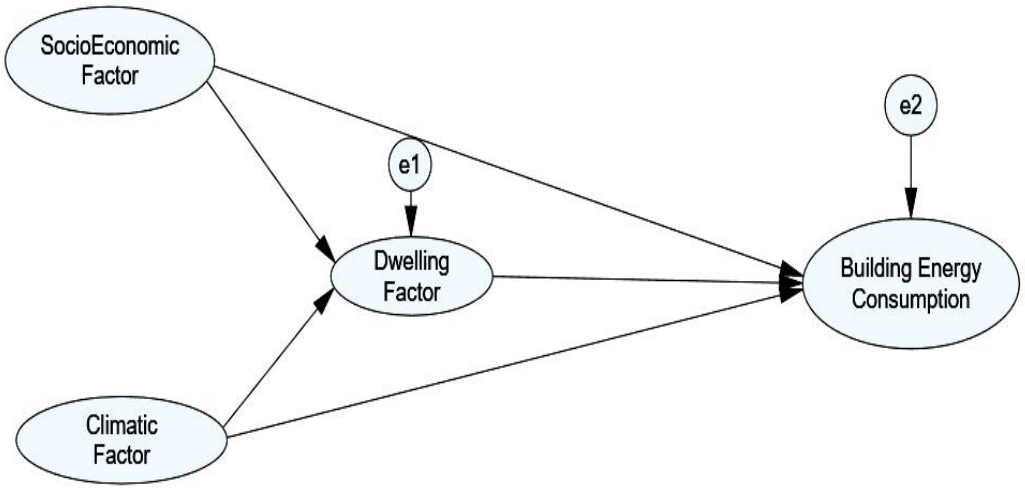

Figure 2: Correlation of Socio Economic, Climate and Dwelling Factors of Building Energy Consumption of Electricity Energy Consumption in Residential Buildings

RESULTS AND DISCUSSION

The final structural model was developed after developing 3 different structural models of socio-economic, dwelling and climate-related energy consumption. The model in Figure 2 portrayed that the Socio-Economic Factor has no significance and no direct effect on residential building energy consumption. However, literature and research conducted shows that, there is a significant and direct effect of socio-economic features on building energy consumption. This implies that, demographic factors, educational background and social background which defined Socio-economic in this research are either playing a negative role or not applicable to the residential occupants of this research as shown in Figure 3.

Overall Model Fit Indices for Structural Equation Model

Overall model fit indices for Structural Equation Model exploring relationship of Socio Economic Factor, Dwelling Factor, Climatic Factor and Building Energy Consumption have been successfully achieved.

Bima Journal of Science and Technology, Vol. 7 (4) Dec, 2023 ISSN: 2536-6041

DOI: 10.56892/bima.v7i4.534

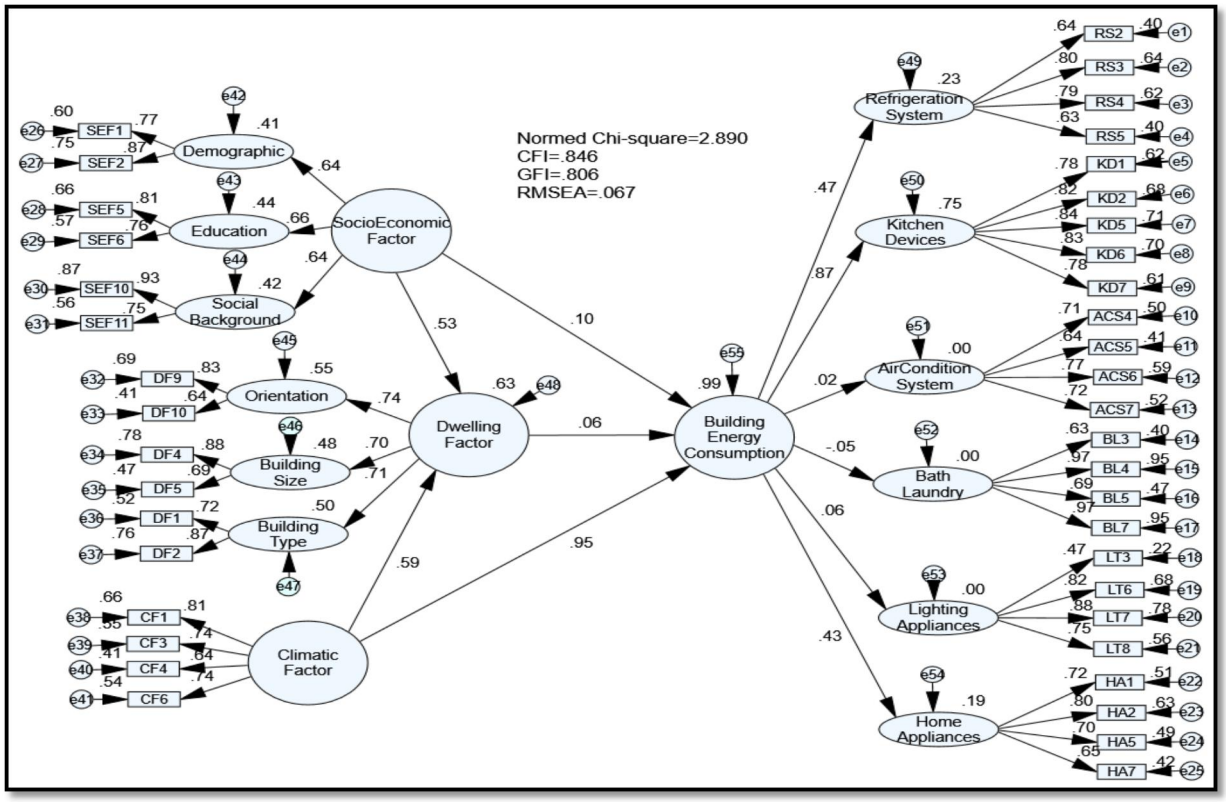

Figure 3: Developed Model of Building Energy Consumption of Electricity Energy Consumption in Residential Buildings.

Discussion on the Model Development

Building Energy Consumption Structural Model consisting of Socio-Economic, Dwelling and Climatic factors with all their indicators are presented in detailed. This was done using SEM (AMOS approach). Multiple regression analysis using path analysis was employed in order to explore the relationship between different constructs of the model. The overall structural model in Figure 3 was measured by 6 constructs through their latent factors, this are, Refrigeration System, Kitchen Devices, Air-Condition System, Bath and Laundry, Lighting and Home Appliances. 15 variables that represent all the factors have a Factor Loading of 0.65 to 0.89 and the loading of the second order is up to 0.79. Ninety three percent (93%) of the overall variance of Building Energy Consumption was accounted by 27% of Refrigeration System, 62% of Kitchen Devices, 21% of Home Appliances with little contribution by Air-Condition System and Lighting. These figures indicate that, occupants understand the impact of Refrigeration System on Building Energy Consumptions. This is represented by 27% through 3 indicators. Variance of RS3 of 61% (Refrigerator defrosting influences building energy consumption). Variance of the RS4 by 65% (Condition of the refrigerator door gasket affects energy consumption). Lastly, variance of RS5 by 43% (Refrigerator's thermostat operation influences energy consumption). In addition, occupants understand the impact of Kitchen Devices on Building Energy Consumptions by 62% through 2 indicators. Variance of KD2 by 69% (Use of high performance kitchen cooker hoods save energy), and variance of KD5 by 73% (Energy consumption is minimized by the use of plastic container for microwave heating).

Moreover, occupants understand the effects of Home Appliances on Building Energy

DOI: 10.56892/bima.v7i4.534

Consumption by 21% through 4 different indicators. 51% of HA1 (Energy is saved when computer energy saver function is activated). 63% of HA2 (There is a reduction in energy consumption when energy efficient fan is used in the house). 49% of HA5 (Use of energy star labelled computer saves energy) and 42% of HA7 (Flat screen monitors, computers save energy instead of conventional types (Cathode Ray Tube). On the same model, figures indicate that the occupants have less understanding on Air-Condition System and Lighting. Figures on Air-Condition System effects on building energy consumption was represented by 3 indicators. AC4 (Regular cleaning of air filter reduces energy consumption) is represented by 44%. AC6 (Ensuring that windows and doors are closed when the air condition is in use (airtight) reduces energy consumption) is represented by 66%. Lastly AC7 (Use of curtains and shades at room openings reduces heat transmission and saves energy consumption) is represented by 52%.

However, this factor contribution is not up to 5% in measuring Building Energy Consumption. Likewise, three indicators represent lighting. LT6 (Switching off lights when not in use saves energy) representing 66%. LT7 (Proper positioning lighting points reduces energy consumption) representing 80%. LT8 (Use of low wattage lamp along the passageway and storerooms saves energy) showing 55%. However, this construct is not measuring up to 10% of the building energy consumption. The highest factor loading is Education (.67) followed by demographic (.65) and lastly Social Background (.63). Socio Economic as an independent construct (Exogenous) was measured by 42% variance of Demographic, 44% variance of Education and 40% variance of Social Background. Demographic was represented by 2 items SEF1 (Factor Loading = .78 and variance = .61) and SEF2 (Factor Loading = .86 and variance = .73). Education is equally represented by 2 items SEF5 (Factor Loading =.81 and variance = .66) and SEF6 (Factor Loading = .75 and variance = .57). Lastly, Social Background is represented by 2 items SEF10 (Factor Loading = .93 and variance = .87) and SEF11 (Factor Loading = .75 and variance = .56). This shows that, there is a significant relationship between Socio-Economic Factor and the 3 constructs (Demographic, Education and Social Background). However, Socio-Economic Factor shows no significance and no direct effect on residential Building Energy Consumption as indicated by the path showing only 2% of relationship.

In this study, the path shows only 24% relationship between Dwelling Factors and Building Energy Consumption. Dwelling in the overall structural model was represented by the construct of Orientation of the building, Building size and Building Type. This implies that this study shows that, there is no significant and direct relationship between Dwelling Factors and Building Energy Consumption. The relationship between Climate and Dwelling was long been studied by many researchers (Belaïd, 2017; Chen, 2017; Tran, Xuan, Nakagami, Kuroki, & Ge, 2022). The study above as reported by different researchers shows a significant relationship between Climate and Dwelling. In this study, the path shows a 61% relationship and a variance of 63% between Socio-Economic and Dwelling Factors. This implies that this study equally shows that, there is significant and direct relationship between climate and Dwelling Factors.

The relationship between Climate and Building Energy Consumption has long been studied by many researchers, (Bazazzadeh, Nadolny, & Safaei, 2021; J. Huang & Gurney, 2016; Li et al., 2021). All the above study shows that there is significant relationship between building energy consumption and climate. In this study, climate has a direct effect on building

DOI: 10.56892/bima.v7i4.534

energy consumption by 80%. In this study, the path shows an 80% relationship between Climate and Building Energy Consumption. Climatic Factor in this research have significant and direct effect on residential Building Energy Consumption.

In conclusion, the study interprets the results found in the developed model. This is in order to accomplish the aim of the research by answering the research hypothesis formulated. If this model is put into practice, the construction industry will benefit from many of its advantages. Benefits in term of carbon emission reduction, savings in cost as well as waste reduction during construction process.

Summary and Discussion

The model identifies the importance of feedback (communication) between the client (property developer) and the customer (building occupants). The example establishes that, if there is good communication between the two parties, the following advantages will be gained;

a) There will be better awareness on the topics of energy sustainability, this will improve energy efficiency. Energy use will be minimized; this means that CO2emission will be trim down in the country. Litigation due to disputes will be brought down. This is because the client gets what he wants. Waste due to re-construction and additional partitions in a newly built houses will be brought down. This will reduce the rate of pollution as waste disposal is another challenge facing construction industry due to unavailability of landfills.

b) The output of this research is significant for identifying the building energy consumption factors which contribute to the greenhouse gas emission in the country. The building energy consumption model was developed to guide the parties involved in the construction process. The findings of this research work will provide the valuable information to the residential building occupants, building developers, policy makers as well as government of Nigeria. The model will help and assist the stakeholders in reducing the skyrocketing increase of carbon emission in the country due to building energy consumption. It will equally help the occupants of residential buildings to better understand the role they are expected to perform in building energy saving.

CONCLUSION

In conclusion, it is quite clear that for a country to have significant and continuous development, it must transform its construction industry. The findings of this research have resulted in the development of a structural relationship model that comprised socioeconomic, dwelling and climate-related factors. Figure 3 shows that, Dwelling Factor, which is defined by the orientation of the building (building positioning), building size and building type, has no significant neither direct effect on building energy consumption. This implies that, the null hypothesis is rejected. This equally shows that, either the occupants are not aware of the role played by Dwelling Factors on building energy consumption or the construction industry is not providing the matching building structures needed for residential purposes.

Recommendation for Future Research

After the completion of this research, a gap still exists on literature based on building energy consumption. The structural relation model developed shows areas considered important on the various aspects of the BEC model in relation to occupants awareness. These are itemized as follows:

i. Research on the conceptual model of BEC implementation strategies needs to be conducted.

DOI: 10.56892/bima.v7i4.534

ii. Areas like occupants attitude should be integrated with BEC in addition to socio-economic, dwelling and climatic related factors.

iii. New research should be employed in commercial buildings using the same approach

Acknowledgement

The authors gratefully acknowledge the support of this research from the Management and Research and Development Unit (R and D) FCE (T) Gombe as well as TetFUND Nigeria.

REFERENCES

Ahmad, T., & Zhang, D. (2020). A critical review of comparative global historical energy consumption and future demand: The story told so far. *Energy Reports, 6*, 1973- 1991.

Ahmed Ali, K., Ahmad, M. I., & Yusup, Y. (2020). Issues, Impacts, and Mitigations of Carbon Dioxide Emissions in the Building Sector. *Sustainability, 12*, 7427.

Aldossary, N. A., Rezgui, Y., & Kwan, A. (2014). Domestic Energy Consumption Patterns in a Hot and Arid Climate: A Multiple-Case Study Analysis. *Renewable Energy, 62*(0), 369-378.

Bazazzadeh, H., Nadolny, A., & Safaei, S. S. H., 10(2), 1. (2021). Climate Change and Building Energy Consumption: A Review of the Impact of Weather Parameters Influenced by Climate Change on Household Heating and Cooling Demands of uildings. *European Journal of Sustainable Development, 10*(2), 1-1.

Becerik-Gerber, B., Lucas, G., & Aryal, A. (2022). The field of human building interaction for convergent research and innovation for intelligent built environments. *Sci Rep, 12*, 22092.

Belaïd, F. (2017). Untangling the Complexity of the Direct and Indirect Determinants of the Residential Energy Consumption in France: Quantitative Analysis Using a Structural Equation Modeling Approach. *Energy Policy,, 110*, 246-256.

Blázquez, L., Boogen, N., & Filippini, M. (2013). Residential Electricity Demand in Spain: New Empirical Evidence Using Aggregate Data. *Energy Economics, 36*(0), 648-657.

Chen, Y. T. (2017). The Factors Affecting Electricity Consumption and the Consumption Characteristics in the Residential Sector-A Case Example of Taiwan. *Sustainability, 9*(8), 1484.

Chong, H. (2012). Building Vintage and Electricity Use: Old Homes use Less Electricity in Hot Weather. *European Economic Review, 56*(5), 906-930.

Churkina, G. (2016). The Role of Urbanization in the Global Carbon Cycle. *Frontiers in Ecology and Evolution, 3*.

Creswell, J. W. (2012). *Educational research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (4 ed.). Boston,USA.: Pearson Education, Inc.

Elnakat, A., & Gomez, J. D. (2015). Energy Engenderment: An Industrialized Perspective Assessing the Importance of Engaging Women in Residential Energy Consumption Management. *Energy Policy, 82*(0), 166-177.

Frederiks, E. R., Stenner, K., & Hobman, E. V. (2015). Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour. *Renewable and Sustainable Energy Reviews, 41*(0), 1385-1394.

Fumo, N., Mago, P., & Luck, R. (2010). Methodology to estimate building energy consumption using EnergyPlus Benchmark Models. *Energy and Buildings, 42*(12), 2331-2337.

Hepbasli, A. (2012). Low exergy (LowEx) heating and cooling systems for sustainable buildings and societies.

DOI: 10.56892/bima.v7i4.534

Renewable and Sustainable Energy Reviews, 16(1), 73-104.

Huang, J., & Gurney, K. R. (2016). The Variation of Climate Change Impact on Building Energy Consumption to Building Type and Spatiotemporal Scale. *Energy, 111*, 137-153.

Huang, L., Bohne, R. A., & Lohne, J. (2015). Shelter and residential building energy consumption within the 450 ppm CO2eq constraints in different climate zones. *Energy, 90* (1), 965-979.

Jones, R. V., Fuertes, A., & Lomas, K. J. (2015). The socio-economic, dwelling and appliance related factors affecting electricity consumption in domestic buildings. *Renewable and Sustainable Energy Reviews, 43*(0), 901-917.

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*(0), 184-194.

Kelly, S. (2011). Do homes that are more energy efficient consume less energy?: A structural equation model of the English residential sector. *Energy, 36*(9), 5610-5620.

Killeen, P. R. (2005). An alternative to null-hypothesis significance tests. *Psychological science, 16*(5), 345-353.

Li, Y., Wang, W., Wang, Y., Xin, Y., He, T., & Zhao, G. (2021). A Review of Studies Involving the Effects of Climate Change on the Energy Consumption for Building Heating and Cooling. *International Journal of Environmental Research and Public Health, 18*(1), 40.

Longhi, S. (2015). Residential energy expenditures and the relevance of changes in household circumstances. *Energy Economics, 49*(0), 440-450.

Masoud Norouzi, Marta Chàfer, Luisa F. Cabeza, Laureano Jiménez, & Boer, D. (2021). Circular economy in the building and construction sector: A scientific evolution analysis,. *Journal of Building Engineering,, 44*, 102704.

McLoughlin, F. D., Aidan Conlon, Michael. (2012). Characterising domestic electricity consumption patterns by dwelling and occupant socio-economic variables: An Irish case study. *Energy and Buildings, 48*(0), 240-248.

Mirrahimi, S., Mohamed, M. F., Haw, L. C., Ibrahim, N. L. N., Yusoff, W. F. M., & Aflaki, A. (2016). The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate. *Renewable and Sustainable Energy Reviews, 53*, 1508-1519.

Myers, D. (2013). *Construction Economics: A new approach* (3rd ed.). New York: Taylor and Francis.

Olanrewaju, A. L., & AbdulAziz , A. R. (2015). An Overview of the Construction Industry *Building Maintenance Processes and Practices*. Singapore: Springer.

Ramírez-Villegas, R., Eriksson, O., & Olofsson, T. (2016). Assessment of renovation measures for a dwelling area – Impacts on energy efficiency and building certification. *Building and Environment, 97*, 26-33.

Rehdanz, K. (2007). Determinants of residential space heating expenditures in Germany. *Energy Economics, 29*(2), 167-182.

Rusek R, Melendez Frigola J, & J., C. L. (2022). Influence of occupant presence patterns on energy consumption and its relation to comfort: a case study based on sensor and crowd-sensed data. *Energy Sustain Soc, 12*(1), 13.

Stangor, C. (2011). *RESEARCH METHODS for the Behavioral Sciences* (J.-D. Hague Ed. 2 ed.). Australia Wadsworth, Cengage Learning.

Štreimikienė, D. (2014). Residential energy consumption trends, main drivers and policies in Lithuania. *Renewable and*

DOI: 10.56892/bima.v7i4.534

Sustainable Energy Reviews, 35(0), 285-293.

Tam, V., Almeida, L., & Le, K. (2018). Energy-Related Occupant Behaviour and Its Implications in Energy Use: A Chronological Review. *Sustainability, 10*(8), 26-35.

Tran, L. N., Xuan, J., Nakagami, H., Kuroki, S., & Ge, J., & Gao, W. (2022). Influence of Household factors on Energy se in Vietnam Based on Path Analysis. *Journal of Building Engineering, 57*, 104834.

Virote, J., & Neves-Silva, R. (2012). Stochastic models for building energy prediction based on occupant behavior assessment. *Energy and Buildings, 53*(0), 183-193.

Xiaoxiao Xu, B. X., Clyde Zhengdao Li,. (2020). Critical factors of electricity consumption in residential buildings: An analysis from the point of occupant characteristics view,. *Journal of Cleaner Production, 256*, 120423.

Zaid, S. M., Myeda, N. E., Mahyuddin, N., & Sulaiman, R. (2015). Malaysia's Rising GHG Emissions and Carbon 'Lock-In'Risk: A Review of Malaysian Building Sector Legislation and Policy. *Journal of Surveying, Construction and Property, 6*(1).