Opportunities for Energy Savings Based on Behavioural Patterns of Residents in Freetown Sierra Leone

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Abstract

Electricity is a major form of energy that is consumed and is also in high demand by the increasing global population of which Sierra Leone is a part. As a result of the high demand competing for the low generation capacity of the utilities, the Ministry of Energy of the Sierra Leone Government, charged with the responsibility of generating and supplying electricity, is unable to meet this demand. The rationale of carrying out this research is to see how raising awareness levels on the significance of energy efficiency practices, as a recommendation through an energy audit process, would help bring a solution to how to meet the high electricity demand.

A quantitative data analysis method was used in this research. A total 120 structured questionnaires were used in collecting data. From the results analysed, respondents agreed that energy efficiency practices in buildings around Freetown, capital of Sierra Leone, would reduce electricity consumption. Furthermore, respondents agreed that an energy audit in buildings around the city of Freetown would help in detecting electricity wastages in these buildings.

Key Words

Energy efficiency, energy demand, energy supply, energy audit, Freetown.

1. Introduction

Freetown, the capital of Sierra leone is a sub Saharan city located in the west coast of Africa. According to the housing and population census conducted in 2015, the population of Freetown was 1,055,964 (SL Census 2015). There is a challenge of electricity access of the inhabitants within Freetown and its environs. There are various factors responsible for the low electricity access within the city of Freetown, which includes low electricity generating capacity and the inefficient use of electricity by residents in Freetown. According to the report on the Sustainable Energy For All (SEFA) mission to Sierra Leone on the 7th and 8th of June 2012 as documented in the National Energy Profile of Sierra Leone (2012), the electricity sub-sector in Sierra Leone faces challenges with only ten percent (10%) of the citizens in the country having access to electricity. According to Kamara (2016), Director of Energy of the Ministry of Energy in Sierra Leone, less than 12.5% of the citizens in Sierra Leone have access to electricity. However, recently the electricity access has increased to 23.40% (World Bank, 2019).

Previous studies within the Sierra Leone Ministry of Energy has shown that one main reason for the inadequate supply of electricity throughout the country, and Freetown in particular, is because of the inefficient use and lack of proper inspection of how electricity is being utilized in buildings and industries which may result in huge losses in the electricity generated (Sierra Leone Strategic Energy Plan, 2009). According to the Sierra Leone Strategic Energy Plan (2016), energy efficiency policy aims to enhance energy access while transforming the energy sector towards greater sustainability, expanding energy supply, increase the current rate of access to electricity, which is at 13%, and power system operations efficiency at 55%. Energy efficiency can be a form of energy generation since it reduces inefficient consumption, frees up power supply capacity, and thereby can provide greater access to electricity for consumers.

The outcome of this research would be of a greater assistance in addressing the problems of inefficient use of electricity in buildings based on resident's consumption attitude. It also addresses how building owners can monitor electricity use in their homes thereby allow us to recommend possible solutions to some of these challenges faced by the country's electricity sector. The outcome of this research, if applied by building residents, might aid in increasing electricity access to off-grid areas and hence help in reducing energy poverty as well as achieving energy security within Freetown and the country at large. As a result of the inefficient use of electricity in buildings within Freetown, it makes it more challenging by the sector of the government of Sierra Leone that is assigned with the task of generating electricity supply throughout the country, to meet the increasing demand of electricity needed within Freetown as there are still areas within Freetown that have no access to electricity. This clearly illustrates that the electricity generated is far below the quantity of electricity demanded for within the city. In the Energy Efficiency Policy of Sierra Leone (2017), the Government of Sierra Leone recognized that regular and stable energy supply is crucial for business and private sector growth (Kamara et al, 2019). Hence, the Government's policy priority in the energy sector is to increase generation capacity across the country, minimize technical and distribution losses and explore other sources of cheap and affordable energy such as renewable energy. The energy sector strategy also highlighted the need to encourage Public-Private Partnerships (PPPs) participation through unbundling of various components such as (generation, transmission, and distribution), etc.

1.1. Electricity Supply in Freetown

Freetown, the capital of Sierra Leone, mainly receives electricity from the biggest hydroelectric power plant situated in Bumbuna, Tonkolili District, in Northern Sierra Leone. It is made up of 161KV transmission lines that runs from Bumbuna to Freetown over a total distance of 250km. The Bumbuna hydroelectric power plant generates power of approximately 30 – 40 MW which provides 40% of electricity to residents in Freetown. During the wet season (which is usually from May to October each year) when rivers are at their peak, the electricity supply from Bumbuna hydro is between 35 – 40MW, This supply reduces drastically to between 10 – 18 MW during the dry season (usually from November to April) that accounts for major power cuts within the capital of Freetown. There is also another 2MW of electricity supplied from a mini hydro power plant situated at Chalotte in rural Freetown. Thermal generators were also installed at Blackhall Road and Kingtom power stations in Freetown with a generating capacity of 15MW. The total electricity generated to supply Freetown is, therefore, less than 100MW. For sustainable electricity supply in the city, approximately 500MW of power supply is needed to power Freetown. As a result of this large gap between the electricity generated and the demand, the need for energy saving practices by residents within Freetown cannot be overstated.

The challenge of low access to electricity supply throughout Freetown might partly be as a result of electricity being wasted or inefficiently used in buildings (Kamara et al, 2019). The main rationale of this research is to raise awareness levels of the relevance of energy savings and energy audit in buildings. The paper assumes that if the level of awareness of the relevance of energy saving and energy audit in buildings is raised, the solution to the challenges of inefficient electricity use or electricity been wasted in buildings will be gradually achieved, as energy saving practice is behavioural. Energy saving practices by residents within Freetown might expand electricity access to off-grid areas in Freetown.

1.2. Significance of Energy Saving

Energy saving in buildings aims at reducing the amount of energy required in providing product and services at affordable prices. For example, the use of light emitting diodes (LED) bulbs in place of traditional incandescent lamps which consume more energy. Energy conservation practice in buildings is essential as the energy demand within Freetown is increasing rapidly. According to Price & McKane (2009), energy saving practice is the most effective means in addressing the concerns over climate change, rising energy prices, and security of supply while at the same time supporting economic growth. According to studies conducted by the Ministry of Energy of Sierra Leone and the UNDP in 2012, the growth in the demand for fuel wood and charcoal is estimated at 3% per annum. Electricity demand, on the other hand, is growing between 6%-7% annually, while consumption of petroleum products is estimated to increase at about 5% per annum. The losses in the production, transportation and use of energy are also high and average 22% annually. System losses in electricity distribution are about 25% while wastage in the end-use of electricity was estimated at about 45% in 2013. Reduction of losses in energy supply and more efficient use of energy would also reduce demand for energy and delay investment in energy supply infrastructure. Previous efforts by the Ministry of Energy and other agencies to promote energy saving practices and conservation in homes and industries have not resulted in sustained adoption of energy efficiency and conservation in the country, owing to a number of financial and institutional obstacles. Previous efforts by the Ministry of Energy and other agencies to promote energy efficiency and conservation in homes and industries have not resulted in sustained adoption of energy efficiency and conservation in the country, owing to number of financial and institutional obstacles (Kamara et al, 2019). From the research carried out by Awawdeh & Tweed (2014), it was agreed that there are two main approaches to save energy in buildings. These approaches are technical and the political. The technical approach guides the designers of the buildings towards more efficient and effective energy-using designs and techniques. While the political approach, enforces the use of specific measures that are considered effective to reduce the buildings consumption of energy.

2. Research Methodology

Designed structured quantitative data questionnaires were used as the major tool in collecting the primary data that was analysed with the use of Statistical Package for Social Scientists (SPSS) version 23 and Microsoft excel software. The primary data was collected by the distribution of 120 questionnaires with the application of random statistical sampling technique and these questionnaires were analysed at various stages in this research. In stage one, a well-organized questionnaire was developed with the aim of collecting quantitative data. Four (4) research questions were developed; data obtained from various sections in the questionnaire are used in providing answers to a particular research question that was developed with the aim of the study in mind and from the results obtained during the review of existing and relevant literature. In addition, for each research question, some statements/questions were developed to collect data for onward analyses and interpretations.

In stage two, the collected data were presented, coded, and subsequently analysed using the Statistical Package for Social Scientists (SPSS) version 23 and Microsoft excel software. The third stage was developed from the discussion of the results obtained in the second stage. In addition, these findings were closely connected with the findings obtained during the literature review in order to determine whether the results were relevant and to see whether an impact was created towards contributing to knowledge in this field of study.

3. Results and Data Analysis

Descriptive and inferential statistics data analyses techniques were used in the data analysis. Tables and graphs were used in descriptive statistics to provide fundamental information about the variables. As a result, frequency tables, histograms and bar charts are used to display how the main variables of this research were distributed.

Table 1: Respondent Gender

	Frequency	Percent
Male	86	71.7
Female	34	28.3
Total	120	100.0

Table 1 is a representation of total participant as per gender, out of the 120 participant there are 86 males and 34 females who participated in the data collection process.

Table 2: Knowledge about Energy Efficiency

	Frequency	Percent
Yes	102	85.0
No	18	15.0
Total	120	100.0

Table 2 represents the extent of how knowledgeable the participants were in relation to energy efficiency practices, this show that 102 were knowledgeable whereas 18 have no knowledge on energy efficiency which represents 85% and 15% respectively of the total responses.

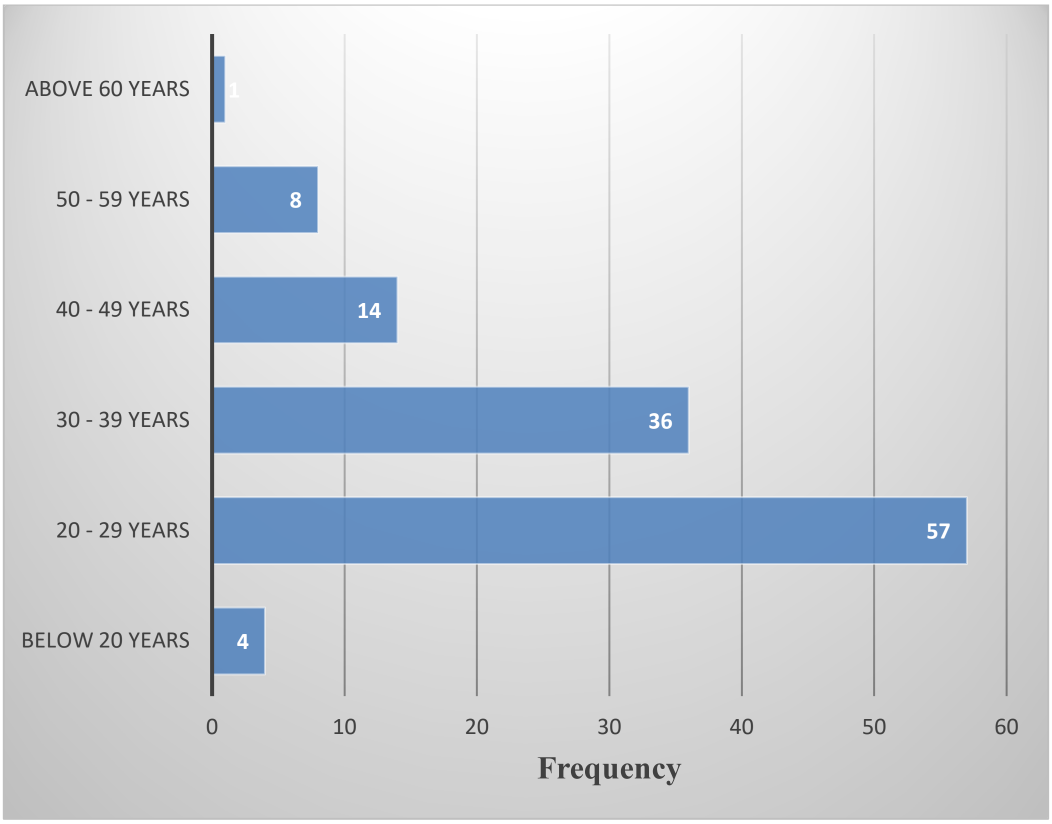

Figure 1: Age Group of Respondents.

Figure 1 is a representation of the age of the participants in the data collection process, majority of the participants in this research falls within the age backets of 20 – 39 years.

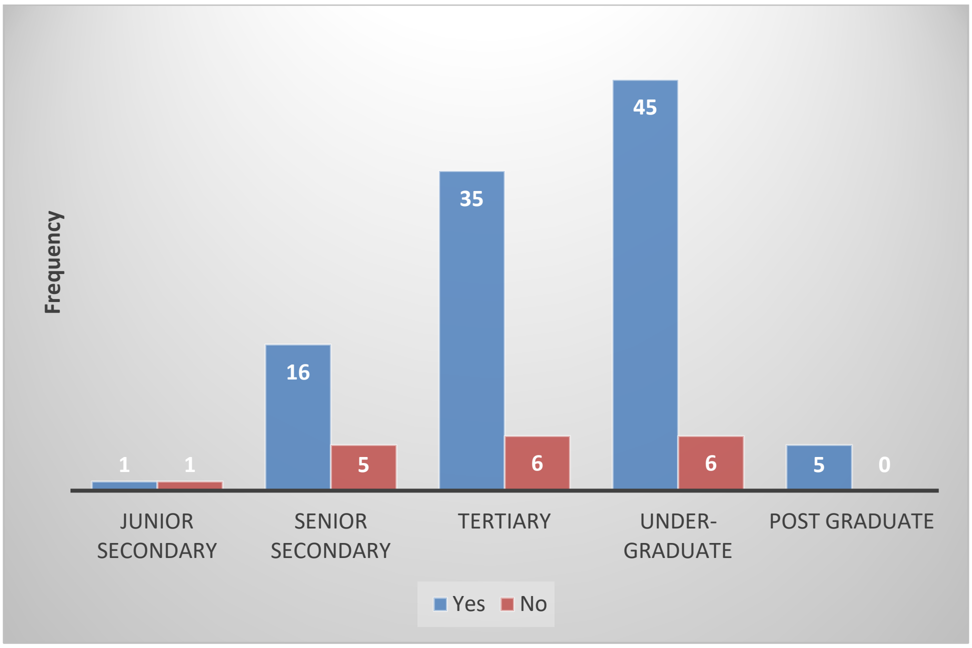

Figure 2: Education and Knowledge about Energy Savings.

Figure 2 displays the respondent's level of education and their knowledge about energy savings, from the histogram it clearly shows that majority of the respondents are well informed about energy savings.

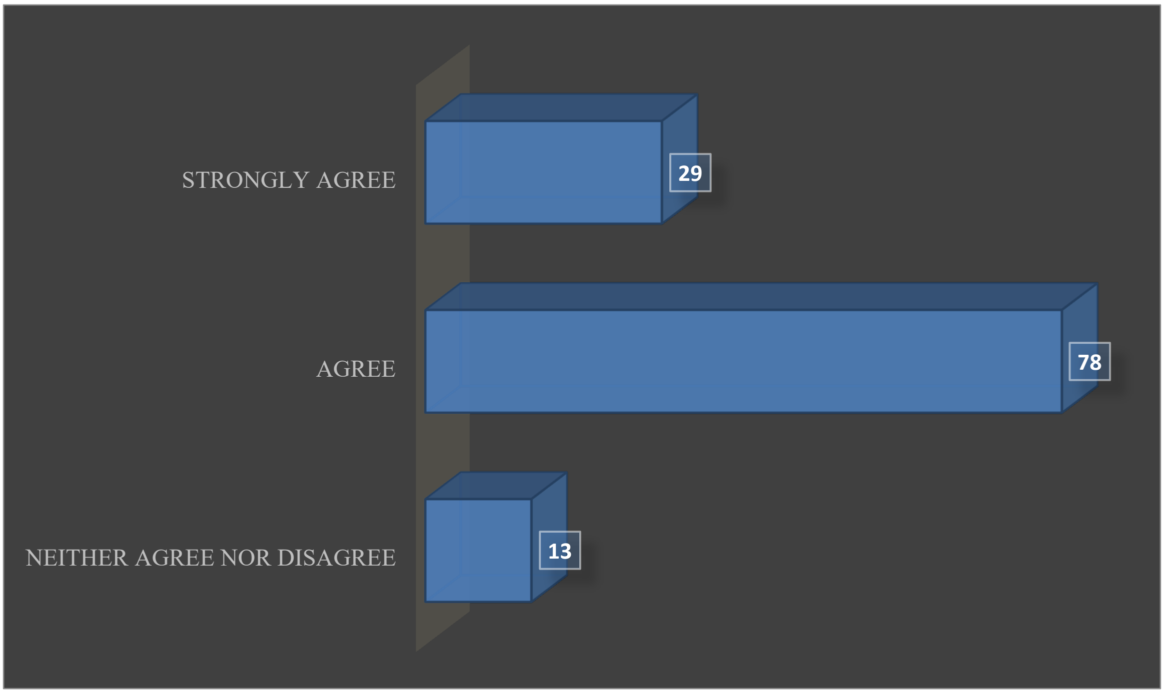

Figure 3: Significance on energy savings in buildings.

From the results displayed in Figure 3, it shows that a greater percentage of the responds agreed that energy saving practice in buildings would impact energy consumption in residents within Freetown.

Table 3: Descriptive Statistics

	Mean	Std. Deviation	Analysis N
IEE1	4.5417	1.46038	120
IEE2	4.2083	1.54428	120
IEE3	3.8417	1.69029	120
IEE4	4.3750	1.29032	120
IEE5	4.8000	1.52624	120
IEE6	4.7583	1.37196	120
IEE7	4.3333	1.36790	120
IEE8	4.6167	1.66114	120

Table 3 gives the descriptive statistics for all the variables under investigation. Typically, the mean, standard deviation, and number of respondents (N) who participated in the survey are given. With a careful look at the mean, one can conclude that IEE5 (i.e. Outlining the significance and benefits of energy efficiency will help in its active implementation of energy saving in homes and offices) is the most important variable. It has the highest mean of 4.8.

Table 4: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.738
Bartlett's Test of Sphericity	Approx. Chi-Square	206.631
	df	28
	Sig.	.000

The KMO (Kaiser Meyer Olkin and Bartlett's Test which measures the strength of relationship among the variables is also a measure of the sampling adequacy which determines if the responses given with the sample are adequate or not) should be close to 0.5 for a satisfactory factor analysis to proceed, Table 2. Kaiser (1974) recommended 0.5 (value for KMO) as minimum (barely accepted), values between 0.7-0.8 acceptable, and values above 0.9 are superb. Looking at table 4, the KMO measure is 0.738, this is above 0.5 and therefore can be acceptable.

4. Discussion

This paper focuses mainly on the behavioural patterns of resident within Freetown towards energy savings. If residents tends to practice a full scale energy saving in their homes this would tend to reduce the electricity wasted and will also minimise the huge losses of electricity in Freetown, if the losses is then reduced there will lead to an expansion of electricity access to off-grid areas. Energy savings in homes is strongly based on behavioural the attitude of residents, if there is a massive sensitisation on its implementation (impact on energy cost, savings etc.) this practice will be widely adopted willingly implemented by residents within Freetown. The implementation and practicing of energy savings in buildings, has the potential of reducing electricity losses and to increase electricity saving. As well as expand supply to off-grid areas, energy saving based on resident behavioural pattern will impact positively on energy studies (Kamara et al, 2019).

5. Recommendation

From the results obtained and analysed in this research it can be recommended that:

- As a solution to increase electricity accessibility within Freetown, the government must increase electricity generation by investing on renewable energy sources.
- Building owners/ occupants must not only depend on the use(s) of product that consume-less electricity as a step towards energy saving but must also apply energy conservation practices in homes (demand-

side management) and offices i.e. switching off all electrical appliances when not in use as this would reduce energy wastage in buildings.

6. Conclusion

The research on the significance of energy saving opportunities based on behavioural patterns of residents in Freetown, capital of Sierra Leone is reported herein. A quantitative data collection method was used in collecting the data in this research, with the implementation of random sampling technique. 120 structured questionnaires were designed and distributed among residents within Freetown as the main source of primary data collection tool. The collected questionnaires were analysed with statistical Package for Social Scientist (SPSS) version 23 and Microsoft Excel in displaying graphs and tables of the analysed data. From the results obtained and data analysed in this research it shows that the implementation of energy efficient practices based on behavioural patterns in buildings by residents within Freetown, would save electricity (Kamara et al, 2019).

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Biographies

Bai Kamara is a Sierra Leonean and holds an undergraduate degree (Bachelor of Science with Honours in Physics) and a Master of Philosophy (MPhil) in Energy Studies from Fourah Bay College (University of Sierra Leone). He is currently a PhD research Student at the department of Mechanical and Industrial Engineering Technology (MIET) Faculty of Engineering and the Built Environment at the university of Johannesburg, South Africa. He is presently working on a research on the development of a Supervisory Control and Data Acquisition (SCADA) program of fouling load for acoustic cleaning of boilers His research interest has been renewable and non-renewable energy generation, efficient energy utilization for domestic and industrial consumption and energy reform processes.

Dr Sheriff Kamara holds two first degrees in Pure and Applied Economics and Mechanical and Maintenance Engineering from the University of Sierra Leone, 2000 and 2004, respectively. He travelled to the United

Kingdom for further studies, where he obtained two master's degrees – Master of Business Management and Master of Science in Management Consultancy (Project Management) from the University of Wales, UK in 2008 and 2009 respectively. Started his PhD studies in Energy Management from 2009 and completed in 2012. Dr. Kamara has worked in industries as well as private practices. He is currently a lecturer in the department of Mechanical and Maintenance Engineering, Faculty of Engineering, Fourah Bay College, University of Sierra Leone, where his current research interests include – Conversion of Wastes to useful products, Design and production of Efficient Cook Stoves, Building Construction project management, etc.

Ing Prof Jonas A S Redwood-Sawyerr is a Sierra Leonean with over 44 years of experience in the University of Sierra Leone. He obtained his BENG degree in Electrical and Electronic Engineering from the University of Sierra Leone, an MSc in Industrial Electronics from the University of London and a PhD in Electronic Systems Engineering from the University of Essex, both in the UK. His research interests are in bandwidth efficient modulations systems, power sector reform, Energy and sustainable development and Engineering education. He is a former Deputy Vice Chancellor of Fourah Bay College and former Vice Chancellor of the University of Sierra Leone.

Dr Daramy Vandi Von Kallon is a Sierra Leonean holder of a PhD degree obtained from the University of Cape Town (UCT) in 2013. He holds a year-long experience as a Postdoctoral researcher at UCT. At the start of 2014 Dr Kallon was formally employed by the Centre for Minerals Research (CMR) at UCT as a Scientific Officer. In May 2014 Dr Kallon transferred to the University of Johannesburg as a full-time Lecturer and later a Senior Lecturer in the Department of Mechanical and Industrial Engineering Technology (DMIET). Dr Kallon has more than twelve (12) years of experience in research and six (6) years of teaching at University level, with industry-based collaborations. He is widely published, has supervised from Masters to Postdoctoral and has graduated seven (7) Masters Candidates. Dr. Kallon's primary research areas are Acoustics Technologies, Mathematical Analysis and Optimization, Vibration Analysis, Water Research and Engineering Education.