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Households' energy conservation and efficiency awareness practices in the Cape Coast Metropolis of Ghana

Abigail Nana Ama Baidoo[1] · Jones Abrefa Danquah[1] · Edward Kweku Nunoo[2] · Simon Mariwah[1,2] · Georgina Nyarko Boampong[2] · Eric Twum[3] · Emmanuel Amankwah[4] · Johnie Kodjoe Nyametso[5]

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Abstract
Thermal power generation is the main source of power in the energy mix of the country. Erratic rainfall patterns, the high cost of fossil fuel for thermal generation, and increase electricity demand have contributed to rampant power outages in the recent past. This paper examined energy conservation and efficiency awareness practices of households in the Cape Coast Metropolis of Ghana. It assessed the level and variability in energy conservation practices and the level of energy-savings awareness education among households. Three hundred and ninety-six households were randomly selected from nine communities using stratified sampling techniques. Five stakeholders from the electricity sector were purposively sampled for in-depth interviews. The data sets were modeled using the utility maximization framework to econometrically estimate socioeconomic factors influencing the energy conservation behaviour of households. The findings reveal that years spent in school by household heads, income levels, expenditure, age of households, and the number of times electricity power triples off daily were among the key factors influencing individual households' choice of energy-efficient appliances. There was significant variability between existing social strata in terms of income and use of electrical appliances among households that warrants policy direction. Based on the findings, this study recommends a robust energy literacy program to improve households' energy efficiency practices awareness, and to ensure energy cost savings, environmental protection, and climate change mitigation that will enhance the drive towards achieving sustainable development goals seven.

Keywords Energy conservation · Energy efficiency practices · Household electrical appliances · Energy literacy · SDG 7

1 Introduction

Energy conservation seeks to reduce the amount of energy needed to achieve optimum energy use. Synonymous with conservation goals, energy efficiency is situated in a context that judiciously appropriates energy through improved energy management systems, consumer behavioural change, and or adoption of novel technology for

✉ Edward Kweku Nunoo, edward.nunoo@ucc.edu.gh; Abigail Nana Ama Baidoo, bigglesanab905@gmail.com; Jones Abrefa Danquah, jones.danquah@ucc.edu.gh; Simon Mariwah, smariwah@ucc.edu.gh; Georgina Nyarko Boampong, ginatomoriginal@gmail.com; Eric Twum, ericktwum@gmail.com; Emmanuel Amankwah, emmanuel.amankwah@uenr.edu.gh; Johnie Kodjoe Nyametso, jknyametso@yahoo.com | [1]Department of Geography and Regional, Faculty of Social Sciences, College of humanities and Legal Studies, University of Cape Coast, PMB, Cape Coast, Ghana. [2]Faculty of Social Sciences, College of humanities and Legal Studies, Institute for Oil and Gas Studies, University of Cape Coast, P. O. Box UC 148, Cape Coast, Ghana. [3]Institute for GreenGrowth Solutions, East Legon, Accra, Ghana. [4]Department of Environmental Management, University of Energy and Natural Resources, P. O. Box 214, Sunyani, Ghana. [5]Department of Environment and Development Studies, Central University, P. O. Box 214, Tema, Ghana.

use of energy resources and electrical appliances [1]. Electrical energy is applicable in all facets of human life and is deemed essential for socioeconomic development. Inferring from Commerford [2], the world's population, postulated to increase by 45% in the next 90 years, is expected to be equally met with energy demand that must not only be readily available, accessible and cheaper but also cleaner to satisfy the net zero carbon demands. The universal call to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030 are key cardinal points of the 17 Sustainable Development Goals (SDGs). Adopted in 2015 by 193 member States of the United Nations Organisation (UNO) in Paris, including Ghana, the SDGs came into effect in January 2016. Also known as Agenda 2030, the SDGs aim to foster economic growth, ensure social inclusion, and protect the environment with five overarching themes; people, planet, prosperity, peace, and partnerships. Among the goals, SDG 7 is specifically dedicated to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. To achieve goal 7 requires robust energy sector development that must depart from conventional sources; transitioning from fossil fuels to renewables, non-conventional clean sources (Nuclear, Hydrogen), carbon sequestration and building resilient energy infrastructure [1].

Global energy demand is on the rise [3]. It is projected to grow by 66% in 2050 from 2020 figures [4] and attributed to increasing population growth rates, especially, in emerging economies, and response to the quest for sustainable economic growth by developing countries [4]. Schwartz et al. [5] and Shaari et al. [6] adduce evidence that demonstrates a significant relationship between energy consumption and economic progress. Consequently, these fast-paced developments have generated significant environmental and economic concerns particularly in developing countries [2]. The tie plays out perfectly well in the annual population growth rates and electricity supply and demand trajectories in Ghana over the decade (Table 1). The interplay depicts a steady annual increase in population growth rates with a corresponding rise in electricity consumption to which corresponding growth in socio-economic development is expected. Marginal rates of electricity supply in Table 1, after 2015 generally looks appreciable in response to increases in energy demand over the period.

The marginal rate of energy demand over the decade has increased faster than supply (Table 1) until after 2015 when unconventional energy sources were mainstreamed [1, 9]. This period, which is sometimes referred to as 'Dumsor' (unannounced on–off electricity power supply), led to persistent deficits in the primary energy supply. Increasing demand was largely attributed to the rise in household energy consumption for various domestic services [10], including charging mobile phones. Per SDG 7, this interplay (An economy with high-energy poverty, high-energy consumption, not readily available clean energy sources and resilient energy infrastructure) needs to be balanced.

In-depth literature on energy conservation and efficiency in Ghana exists [1, 11, 12]. They adduce the fact that various measures have been initiated to create awareness and to educate people on energy conservation and how to utilize energy judiciously [13–15]. However, very few studies have assessed households' roles in energy conservation and efficiency dynamics in the Cape Coast metropolis. The main goal of this study is to assess and analyse scientifically, energy conservation and efficiency practices, and present assessment results on households' energy consumption on electrical appliances in the Cape Coast metropolis. Guided by three hypothetical questions underpinning the objectives of the

Table 1 Annual population growth and electricity demand in Ghana (2009–2019). *Source*: Based on Energy Commission of Ghana (2020) [7], and Ghana Statistical Service (2020) [8] data

Year	Population (millions)	Electricity supply (Mw)	Marginal rate of supply (Mw)	Electricity demand (Mw)	Marginal rate of increase (Mw)
2009	24,170,940	1423	–	1263	–
2010	24,779,619	1506	83	1391	128
2011	25,387,712	1665	59	1520	129
2012	25,996,450	1729	64	1658	138
2013	26,607,645	1943	214	1791	133
2014	27,224,473	1970	27	1853	62
2015	27,849,205	1933	−37	1757	−96
2016	28,481,945	2078	145	1997	240
2017	29,121,465	2192	114	2077	80
2018	29,767,102	2525	333	2371	294
2019	30,417,856	2804	279	2613	242
2020	31,072, 940	3090	286	2857	244

study, the paper specifically assessed the level of energy conservation awareness among households, examined efficiency practices and analysed socio-demographic factors influencing households' choice and use of electrical appliances in the Cape Coast Metropolis. In line with the objectives set for this study, the following hypothesis was developed;

i. H_0: There is no statistically significant difference in energy conservation practice among households in the Cape Coast metropolis.
   H_1: Statistically, there is a significant difference in energy conservation practice among households in the Cape Coast metropolis.
ii. H_0: There is no statistically significant relationship between income level and energy-saving practices among households in the Cape Coast metropolis.
   H_1: There is a statistically significant relationship between income level and energy-saving practices among households in the Cape Coast metropolis.
iii. H_0: There is no statistically significant relationship between socio-demographic factors and the choice of energy-efficient appliances among households in the Cape Coast metropolis.
   H_1: There is a statistically significant relationship between socio-demographic factors and the choice of energy-efficient appliances among households in the Cape Coast metropolis.

The significance of this study lies in its potential to inform energy efficiency policy and strategies for advancing sustainable economic development in the Cape Coast metropolis by creating awareness to conserve energy and adherence to best practices that will achieve sustainable development goal seven (SDG 7) by 2030. Beyond contributing to the literature, the findings of this study would also deepen understanding of awareness creation of energy efficiency practices among households.

2 Literature review

2.1 Historical perspectives on energy conservation and efficiency

In direct response to the global oil price increases of the 1970s and the 1980s, high energy-intensive consuming countries became concerned and saw a need to cut down on energy consumption [16–18]. Some countries reviewed their existing energy policies and incorporated energy conservation and later, energy efficiency practices as key aspects of their national energy policies [16]. This was in response to an increase in judicious utilization of energy resources across the divide. In 1973, the San Diego California community in the United States of America initiated an energy efficiency program that integrated employee awareness campaigns to conserve energy through de-lamping, thermostat setbacks and revised operating procedures on the built environment energy systems [19, 20]. It resulted in a 37% energy savings or 7 million kilowatt hours per year [19, 21]. Subsequently, emergency energy conservation initiatives were introduced by many other national governments. Policies were adopted, formulated and initiated to promote the rational use of energy. Energy conservation centres were established as parastatal budget Organisations to implement National Energy conservation programs such as those in South Korea the Korean energy management corporation-KEMCO in South-Korea and the Energy conservation centre-ECCJ in Japan [22, 23]. In Australia and New Zealand emphasis on energy conservation measures were on projects aimed at reducing energy import requirements. Achieving a global perspective [22], this led to the enactment of an Energy Conservation Promotion act (ECPA) in Thailand (1992) and the Philippines' Department of Energy Act (PDoEA) in the same year. In 1995, the Iran Energy Efficiency Organization (SABA) was established as a budgetary parastatal while a Federal Law on Energy Savings (FLoES) was adopted by the Russian Federation in 1996. In Uzbekistan, the legislature passed a national law on rational use of energy (RUE) in 1997 whilst several other countries adopted energy audits practices which became mandatory for large-scale industrial energy consumers [6, 24–26]. Benefits associated with these conservation initiatives were recorded in terms of both energy and financial savings making energy efficiency measures an important component of industrial practices in both developed and strongly emerging economies across the globe [1]. In recent years, however, there has been a gradual paradigm shift from the earlier "*energy conservation*" policy goals and concepts, to "*energy efficiency*" policies and goals. Efficient electrical appliances' uses of energy will not only save households' income spent on energy but is also seen as an indispensable tool in the fight against climate change. The increasing role of active energy efficiency promotion towards achieving SDG) 7 and zero net carbon dioxide (CO_2) emissions has become the new norm as embraced by the United Nations Organisation's (UNO) Member States.

2.2 Determinants of Energy saving behaviour

The energy conservation behaviour of households or an individual is influenced by a multiplicity of factors. These drivers of energy-saving behaviours can be broadly categorized into psychological, sociological, economical and environmental factors [27–32]. Various theories have been propended to explain energy-saving behaviour the most notable among them is the theory of planned behaviour [31, 33–36]. Other behavioural models such as energy ladder and stacking have been used to describe energy choice, switching and transition behaviour of the households [37–39]. Energy-saving behaviour of individuals in residential buildings is greatly influenced by characteristics related to factors such as age, size, income, education level, type of occupancy, and length of residency of householders [40]. Environmental drivers related to the physical characteristics of the building and the immediate surroundings influence the energy conservation behaviour of individuals [40, 41]. Other sociodemographic factors have been cited to influence energy conservation behaviour [41–44]. Using the theory of planned behaviour, Alomari et [45] reported that societal pressure and cultures significantly affect individual intention to engage in energy conservation behaviour.

2.3 Energy conservation and efficiency practices in Ghana

Energy conservation and efficiency management activities in Ghana range from relatively inexpensive and easily implementable actions, which are referred to as "low-hanging fruits" management [1]. These include turning off lights and switches when not in use and adhering to the use of energy-efficient appliances, too-expensive technology such as using electric sub-meters to monitor and improve consumption use of alternative energy sources [46] and the use of artificial intelligence [9]. According to Capehart et al. [22], it is advisable to work on these easier actions ("low-hanging fruits") and use benefits accruing to continue with higher levels until policy targets are attained, gains sustained and or improved upon. The Ministry of Energy and related allied agencies, since 2005, have rolled out and implemented key policies to manage inefficient distribution and use of energy. These include incentive-based policies to mandatory measures to regulate demand for energy products in the country [47]. The Ghana energy and efficiency policy in 2005 was part of a broader national energy policy that addressed all issues in the energy sector of the economy. The goal was to ensure efficient energy production, transportation, and use of energy in Ghana [15] by establishing an appropriate pricing regime to induce domestic and industrial consumers to voluntarily manage their energy and also to support the education and awareness creation on the methods and importance of energy conservation [1].

A regulation, triggered by legislative instrument (LI) 1815 in 2005 (Energy Efficiency Standards and Labelling Regulation) mandated manufacturers, importers and retailers of home electrical appliances to label all such gargets sold on the Ghanaian markets to indicate their efficiency levels and ensure that the appliances meet efficiency standards of the regulation [1, 10]. This was followed by the efficiency lighting project in 2007 to replace all incandescent lamps with Compact Fluorescent lamps. About 6 million energy-saving bulbs were distributed, saving Ghana 124 megawatts of electricity ($ 300 million) in just three years after its implementation [48]. A year after (2008), the energy efficiency regulation (LI) 1932, was in force to prohibit the importation and use of second-hand home electrical appliances including television sets, refrigerators, fans, pressing iron, heaters and freezers [49, 50] which had become absolute in terms of energy consumption. By way of intervention, the policy discounted and promoted the use of new and energy-efficient home electrical appliances such as refrigerators and freezers to bait persons in possession of second-hand electrical appliances and trade them for new efficient ones. About 400GWh of electricity and 1.1MT carbon emissions were saved through the refrigerator rebate and turn-in scheme [49, 51]. Despite all these interventions, large sections of the Ghanaian population, including the Cape Coast municipality, are still indifferent to energy conservation and efficiency practices [15, 52].

2.4 Energy conservation in the Cape Coast Metropolis

Inferring from the nationwide energy use survey data, initially published in 2012 and subsequently reviewed annually (Energy Commission, Ghana 2021), the average annual electricity consumption by key home electrical appliances sampled per household (kWh) in the metropolis depicts a snapshot (Table 2) of the situation on ground with a consumption rate of 1.5%. Electricity demand in the metropolis for residential and non-residential as of September 2019 stood at 4,829,916.05 kWh and 1,019,158.59 kWh respectively [7]. In a quest to intensify energy-saving practices among households, energy institutions embarked on energy-saving campaigns in Cape Coast to educate households on conservation and efficiency practices. Electricity demand in the metropolis for residential and non-residential as of September 2019 stood at 4,829,916.05 kWh and 1,019,158.59 kWh respectively [7]. In a quest to intensify energy-saving practices among households, energy institutions embarked on energy-saving campaigns in Cape Coast to educate households on conservation and efficiency practices. This resulted in the use of energy-efficient bulbs that requires less energy to produce the same levels of energy services [52].

Financial constraints, however, have been cited as a key reason why households will opt for inefficient electrical appliances [53]. Kwakwa and Adu [11] identified other factors that include demographical features, information and concern for the environment, dwelling characteristics, subjective norms and perceived benefits as also paramount in conserving electrical energy among households. Energy users are more likely to reduce their consumption when they develop strong personal norms as they will morally be obliged to perform such practices [54].

2.5 Energy conservation awareness and information dissemination

Many researchers have highlighted the role of consumer awareness in electrical energy conservation [1, 11]. It is reported that excessive electricity consumption may be attributed to wasteful practices by users [11]. Consumers exhibit these wasteful practices due to inadequate knowledge of or awareness of the use of energy efficiently and its related implications [55]. For Ouyang and Hokao [56], people tend to be unconcerned about energy efficiency problems because of their ignorance of the relation between daily energy use that has resulted in the socio-economic problems faced by households and the global environmental impact in the world today. Affected directly by human attitudes and cultural tendencies [38], energy conservation and efficiency awareness campaigns will enable households to relate energy use to their socio-economic problems and the continuing warming of global surface temperatures [11, 57, 58]. The best way to be electrical energy efficient is to be aware of how energy is used [59]. Increasing electricity conservation awareness eliminates consumer apathy towards the judicious use of electricity [10]. It has a high probability of inducing households to adopt energy-saving practices [60]. Thus, the massification of awareness and the ability to control usage is an effective means to implement energy efficiency policies [14, 56]. Energy efficiency campaigns and awareness creation is, therefore, effective tool that can help ensure energy conservation among consumers [8, 61].

3 Context and methodology

3.1 Case study area

The Cape Coast Metropolitan Assembly in the Central Region is one of the 22 Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana. The municipality lies within latitudes 5^0.07′ to 5^0.20′ north of the Equator and between longitudes 1˚0.11′ to 1˚0.41′ west of the Greenwich Meridian with a total land area of approximately 122 sq. km (12,200 ha). It is bounded on the East by Abura-Asebu-Kwamankese District (A.A.K), to the West by Komenda-Edina-Eguafo-Abrem (K. E. E. A.) District, to the North by Twifo-Heman Lower Denkyria District (T.H.L.D) and to the South by the Gulf of Guinea (Fig. 1). The choice of Cape Coast municipality as the case study is informed by two important factors.

Table 2 Annual average electricity consumption of electrical appliances (KWh/household). *Source*: Based on ECG, 2020

Region	Electrical appliances					
Central	Refrigerators	Lighting	Television	Fan	Iron	Other
	876.6	233.0	116.9	112.3	51.1	43.8

First, the metropolis serves as the Central Region's administrative capital with a number of very good second cycle schools and tertiary institutions (the University of Cape Coast and Cape Coast Technical University) in Ghana. Economic activities include fishing, trade and Government administration. Second, the municipality is well noted for its ecotourism endowment and cultural-heritage tourist attractions that can be traced down to the era of Ghana's early encounter with the European trade in gold, ivory, and later the infamous slave trade. The university of Cape Coast, with its expanding satellite communities, is the largest consumer of electricity in the metropolis. The target population for this study is households in the metropolis. Primary electrical energy users (household heads) were selected from each household as respondents to the study.

3.2 Sampling procedure and research instruments

The research was carried out over three months (July–September) in 2021. Out of the total population of 40,386 households in the Cape Coast metropolis [8], a sample size of 396 households were selected to participate in the quantitative field data for this study [62, 63]. The total population of 40,386 households [8], was divided into 3 strata (high income, middle income and low-income communities). A sample size of 396 households was selected based on Glenn [64]. Three communities were selected from each stratum (9) using the lottery version of the simple random sampling procedure. After the communities were identified, the total sample size (n = 396) was divided among the 9 communities and 44 households were identified as respondents from each selected community using the convenience sampling method. Questionnaires and interview guides were employed to collect qualitative data after obtaining ethical cleared from the University of Cape Coast (UCC). Five in-dept interviews were purposively conducted with identified stakeholders from the Electricity Company of Ghana, assembly members who are also community leaders and representatives of their various communities in the Local Government. The Kobo collect Application (KCA) was used to collect the quantitative field data. Pre-testing was done by screening the research instruments with faculty members and other staff within the Geography and Regional Planning Department at the University of Cape Coast after which the instruments were revised. During the pilot test, questionnaires were administered to 20 respondents through the convenience sampling technique at the Kwaprow village in the Cape Coast metropolis (Fig. 1). The qualitative method complemented the quantitative measurements for the study.

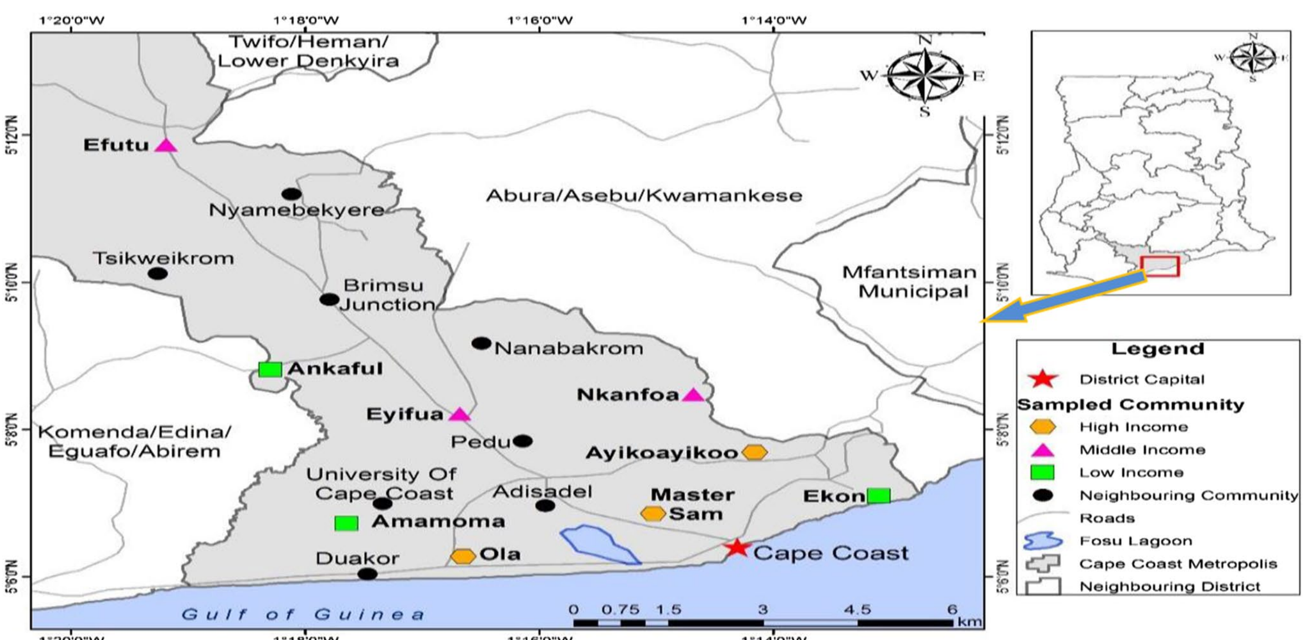

Fig. 1 Study area map of Cape Coast Metropolis. *Source*: Authors' construct, 2021

3.3 Theoretical framework

This paper is grounded in behavioural economic theory. Behavioural economics recognises that people do not always make choices that maximise their welfare despite best intentions. However, even in the absence of perfect information, it is assumed that people will choose the option that results in their highest welfare based on available information [70, 71, 79]. A behavioural change is requisite to achieving energy conservation at the individual level. Khan and Halder [57] purport that domestic energy consumption is closely related to the consumer's energy-saving awareness, which is also related to selecting or choosing new efficiency appliances. The efficient consumption of electricity contributes to the security of sufficient supply, energy saving, and reduction of consumption costs. Electrical energy saving through behaviour change, even without capital cost, could be a great option to meet the increasing demand rather than increased electrical energy generation.

3.4 Analytical and conceptual framework

Households' decision to choose energy-efficient appliances is influenced by socioeconomic conditions or the environment in which they operate [65]. Thus, a household's (or individual) decision to use energy-efficient appliances is based on the satisfaction derived from the use of such an electrical appliance. Modelled on the utility maximization framework, the utility of using an energy-efficient appliance is denoted by U_{1i} and the decision not to use an energy-efficient appliance by U_{0i}. According to Asinyaka [45] however, U_{1i} and U_{0i} are latent variables expressed as follows:

$$U_{1i} = X_i\beta_1 + \varepsilon_{1i} \tag{1}$$

$$U_{0i} = X_i\beta_0 + \varepsilon_{0i} \tag{2}$$

where X_i is the vector of the individual or household characteristics, and epsilon ε(s): ε_{1i} and ε_{0i} are random errors terms, hence household or individual *i* who uses energy-efficient appliance is given as:

$$U_{1i} > U_{0i} \rightarrow \varepsilon_{0i} - \varepsilon_{1i} < X_i(\beta_1 - \beta_0) \tag{3}$$

Individual *i* utilizes energy–efficient appliances when $U_{1i} > U_{0i}$, then y_i is equal to 1, otherwise $y_i = 0$. Hence, the probability that $y_i = 1$ is given as $\Pr[\varepsilon_{0i} - \varepsilon_{1i} < X_i'(\beta_1 - \beta_0)]$. This probability has a dichotomous outcome. However, this particular instance *y* was parameterized using an index that takes on values 0, 1, 2,…n. The special nature of the dependent variable y means that it cannot be estimated using ordinary least squares. This is best estimated using the Poisson regression model. The probability function of Poisson distribution for the number of occurrences of the event is given as:

$$f(y_i|X_i) = \frac{e^{-u_i}\mu_i^{y_i}}{y_i!}, \quad y_i = 0, 1, 2, \dots, \tag{4}$$

where y_i is count the discrete number of events or random variable, and the mean parameter and the variance equal to u_i. This is one parameter distribution [66]. To add exogenous variables X_{ij} ($j = 1, \dots K$), as well as a constant, the parameter u_i is specified to be:

$$\mu_i = \exp(X_i''\beta) \tag{5}$$

$$\text{Consequently, } E[y_i] = u_i = e(X_i\beta) \text{ and } V[y_i] = u_i = e(X_i\beta) \tag{6}$$

Given Eqs. (4) and (5) based on the assumptions that the observation $(y_i|X_i)$ is independent the usual estimator is the maximum likelihood (ML) [66]. The log-likelihood function is

$$\ln L(\beta) = \sum_{i=1}^{n} \left\langle y_i X'\beta - \exp(X_i'\beta) - \ln y_i! \right\rangle \tag{7}$$

The maximum likelihood estimator for Poisson is represented as $\hat{\beta}_p$ for the solution to K non-linear equations, and the first order maximum likelihood condition is given as:

$$\sum_{i=1}^{n} \left(y_i - \exp(X_i'\beta)\right)X_i = 0 \quad (8)$$

Equation (8) can be solved using the Newton–Raphson algorithm to obtain the parameter estimates. Based on Cameron and Trivedi [67] and Danquah et al. [13], the empirical model of the Poisson regression model in this study is specified as:

$$y_i = e^{X_i\beta} + \varepsilon_i = e^{(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+.......+\beta_kX_k)} + \varepsilon_i \quad (9)$$

where y_i refers to an index for using energy conservation appliances and X_i(s) are explanatory variables that represent all social demographic factors that influence households' decision to choose energy-efficient appliances or energy conservation behaviour of households. The ε_i sign is an error term and $\beta(s)$ are the parameter estimates in the model. Equation (9) was estimated using maximum likelihood methods within the framework of the Newton–Raphson algorithm in STATA. A detailed description of the predicators (explanatory variables) is given in Table 3.

3.5 Dependent variable

The dependent variable was derived from four indicators variables (*Awareness, Energy-saving practices, Choice, Conservation practice variation)* that measure efficiency of an electrical appliance. A set of questions were asked to assess respondents' level of *Awareness*: Each item is assigned a value of one (1) or zero (0) depending on the response from the respondent. Hence the total score under awareness is four (4). The awareness questions are on the importance of electricity conservation, knowledge of policy, efficiency label, and information source. *Energy-saving practices* questions elicit responses on 4-point scale ratings, these are "sometimes (2)", "always(3)", "rarely (1)", and "I don't/Not available(0)".The maximum score under energy-saving practices is 3 and the lowest is 0. The *choice* variable is measured on a 10-point scale. Items considered under this variable are; 'efficiency', 'size', 'location', 'durability', 'weight', 'cost', 'appearance', 'affordability', 'income', 'and reliability'. Each of these items attracts a value of 1 or 0 depending on the response from the respondent (household head). The maximum score under this indicator variable choice is 10. The *Conservation practice variation* indicator variable examines 2 items; 'income' and 'location' and this has a maximum score of 2 and minimum score of 0. The four indicator measures for energy-efficient appliances are aggregated into a composite variable with the highest score of 19 and the lowest of 0. Hence the index for the dependent variable is equal to Awareness(4) + Energy-saving(3) + choice(10) + Conservation practice variation(2) = 19. This is under the condition that the individual household head scores the highest rating for all four indicator variables.

3.6 Data analysis and management

The deductive data analysis approach (multiple regression, correlation and T-test) was used for analysing quantitative data. Microsoft Excel, 19th edition was used to clean gathered data and also to process data for analysis. Statistical Package for Social Science, version 23 was used to run the analysis. Results obtained from the analysis are presented in tables, graphs and charts.

4 Results and discussion

4.1 Level of educational

The study analysed the educational level of household respondents in the communities as a key demographic attribute. The impact of education on the adoption of efficient technology and efficiency measures, which ultimately affect the efficiency of household electricity consumption has been studied [68]. Whereas Prete et al. [69] established a positive relationship between intentions to adopt efficiency measures and higher levels of education among Southern Italian households, Poortinga et al. [70] concluded in their findings that attaining higher education by household heads leads to low energy consumption. Figure 2 shows returned responses to the different levels categorized into tertiary, senior high, junior high and basic, and no formal education. Gleaning to the chart, only 13% of the respondents had no formal

Table 3 Definitions of explanatory variables and expected signs. *Source*: Based on field data, 2021

Variable	Definitions	Sign	Continuous variable		Categorical variable (%)
			SD	Mean	
Sex	This measures the gender and social role of the household head. Male = 1, Female = 0	±			Male(1) = 35.9 Female(0) = 64.1
Age	Age of the household head, both de facto and de jure in years		14.5	40.64	
Social Stratification (Strat)	This measures zonation. Suburban areas are stratified into income levels. That is affluence:High = 1 Middle = 2; Low = 3	±			High = 33.3 Middle = 33.3 Low = 33.3
Marital Status	This measures whether the individual is married or not	±			Single = 32.6 Married = 46.5 Cohabitation = 7.3 Separated = 3 .8 Widowed = 6.8 Divorced = 3.0
Years of Schooling (Ysch)	This total number of years the household head spent at school to acquire education /skills/ competencies	+	5.09	9.35	
Years of Residence (Yresi)	The total number of years spent or stayed in the current residential facilities	+	12.4	13.6	
Expenditure (Exp)	Daily expenditure of the households	+	21.45	39.33	
Income	Total monthly income from all sources	-	200	450	
Household size (HHsize)	This measures the number of individuals in the household who eat from common cooking pot and above 18 years of age	+	2.6	6.7	
BeEight	Individuals in the household who are below eighteen years of age, that is a dependence ratio	+	1.99	2.8	
Hphour	Total hours in a day households' lights are switched off	+	0.83	1.69	
Monthly electricity expenditure (MonEExp)	The proportion of income spent on electricity bills	+	45.8	100	

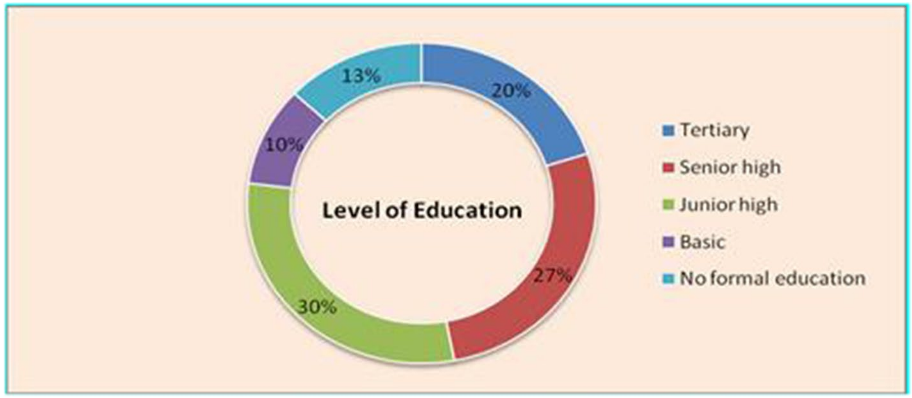

Fig. 2 Level of education. *Source*: Based on field data, 2021

education (Fig. 2). This is an indication that any energy conservation and efficiency awareness education policy could achieve its main goal if a conscious effort is made to educate all households.

Years of schooling is identified in the model (Table 8) to be positively associated with the energy conservation behaviour of households. According to Tewathia [71] and Poortinga et al. [72], household heads with higher educational levels or achievement are more likely to be well-enlightened or knowledgeable in energy conservation/saving practices. The impact of years of schooling is however observed not to be significant (P = 0.017) and supports Wang et al. [73], (2011) stance that no significant difference exists in the energy-saving practices of residents across the different levels of education in the metropolis.

4.2 Household size

Figures 3 and 4 show the distribution of returned responses on the household size from among five (5) accommodation types. The majority of the respondents (84.4%) have household sizes ranging from 1 to 6 persons. The average household size in the metropolis (Fig. 4), however, falls within the national average of 4 persons per household [8]. This outcome is informing since it could be useful as statistics for planning to determine the choice and use of electrical appliances in households in the metropolis.

A number of studies [74–76] have concluded on high energy consumption practices in households with higher occupancy rates. Jones et al. [77] argue that the presence of youth in households leads to a significant increase in residential electricity consumption. From the model (Table 6), however, household size is inversely related to energy conservation practices and is also significant (− 0.0051189). Based on the economies of scale theory, the outcome supports Filippini and Hunt's [78] findings on the subject which explains that as family size increases, there is a tendency to use less energy per person in residential energy consumption. Households with a high dependence ratio, with more members below the age of 18 are more likely to adopt any conservation practices, including the use of energy-efficient household appliances [79].

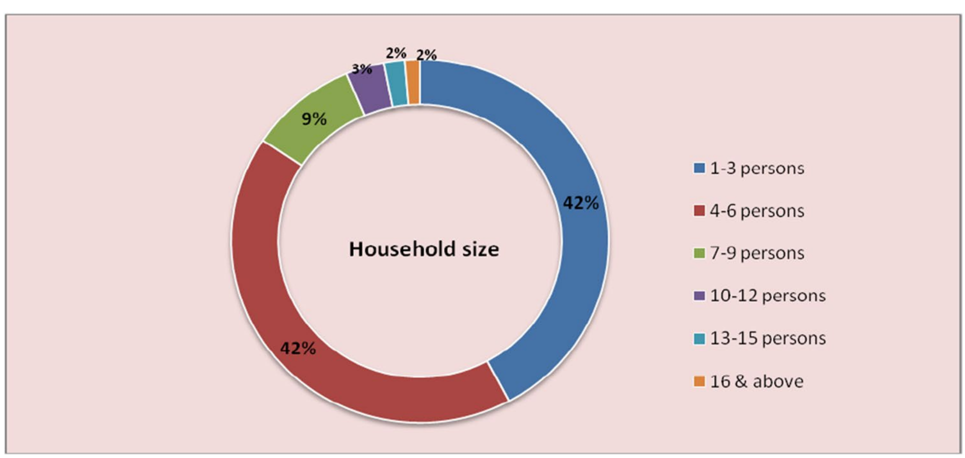

Fig. 3 The household size of the respondents. *Source*: Based on field data, 2021

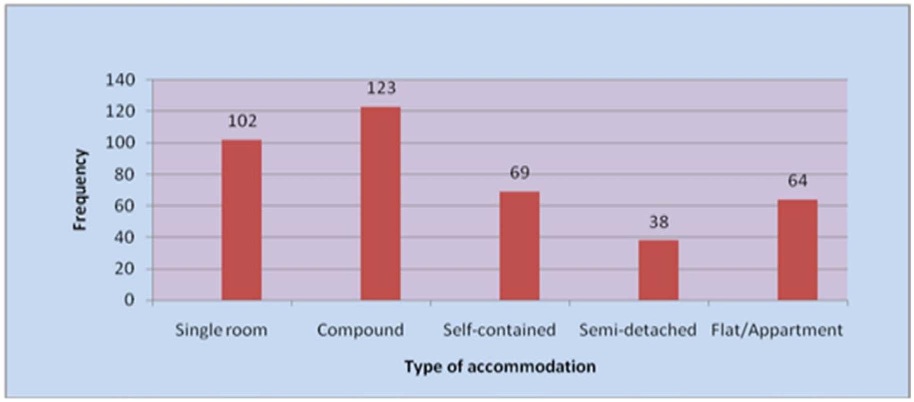

Fig. 4 Respondents' accommodation type. *Source*: Based on field data, 2021

4.3 Age distribution

The Cape Coast Metropolis has youthful population dynamics not different from the national average demographic characteristics [8]. Studies have shown that the adoption of efficient technologies is negatively related to age [60] and that the aged are less likely to adopt efficient appliances [78]. From Table 4, the majority of the respondents (82%) fall within the youthful age brackets (18–47 years). This finding collaborates assertions of Kotsila and Polychronidou [79] and Sardianou [60] on the inverse relationship existing between age and the adoption of efficient appliances. Inferring from Table 6, the model shows age to be negatively ($P = -0.0002008$) associated with the energy conservation behaviour of households but significant ($P < 0.05$). Only 13.1% of respondents (Table 4) were found within the formal retirement age (58–63 years) suggesting that any energy conservation and efficiency education policy that consciously targets the youth will succeed in achieving its main goal [12].

4.4 Household income

Income is one of the major socioeconomic variables which have a significant influence on the household decision to conserve energy or use energy-efficient appliances [80]. Household electricity consumption is positively related to levels of household income [81]. This implies the more income a household earns, the most likely they would be able to conserve energy or choose energy-efficient appliances. Table 5 depicts employment data in the metropolis that shows more than half of the respondents (60.9%) are self-employed. However, they are also identified within the lowest income earner brackets (¢200-¢1200 [$32-$189]). The outcome supports data from the 2020 Population and Housing Census report that classifies the majority of Ghana's economically active population as self-employed.

Table 4 Age distribution. *Source*: Based on field data, 2021

Variable	Frequency	Percentage (%)
Age		
18–22 years	14	3.5
23–27 years	65	16.4
28–32 years	66	16.7
33–37 years	51	12.9
38–42 years	47	11.9
43–47 years	41	10.4
48–52 years	36	9.1
53–57 years	24	6.1
58–62 years	16	4
63 years and above	36	9.1
Total	396	100

Table 5 Socio-demographic characteristics (Occupation and Income). *Source*: Based on field data, 2021

Variable	Frequency	Percentage (%)
a. Occupation		
Unemployed	47	11.9
Self-employed	241	60.9
Public servant	53	13.4
Private institution	24	6.1
Other	31	7.8
Total	396	100
b. Ave. monthly income		
GH¢200 and below	115	29
GH¢201–GH¢700	181	45.7
GH¢701–GH¢1200	54	13.6
GH¢1201–GH¢1700	24	6.1
GH¢1701–GH¢2200	10	2.5
GH¢2201–GH¢2700	5	1.3
GH¢2701–GH¢3200	2	0.5
GH¢4201 and above	5	1.3
Total	396	100

Table 6 Socio-demographic factors influencing the choice of energy-efficient appliances. *Source*: Based on field data, 2021

Variable	Coefficient	Standard error	Z-Statistic	Prob.
Sex	0.0308245	0.0265194^{NS}	1.16	0.245
Age	−0.0002008	0.0009946^{NS}	−0.20	0.840
Strat	−0.0234528	0.0191197^{NS}	−1.23	0.220
Marital	−0.052799	0.0116961****	−4.51	0.001
Ysch	0.0178127	0.0027238****	6.64	0.001
Yresi	0.0003079	0.0001547**	1.99	0.047
Expenditure	0.0008203	0.0001121****	7.32	0.001
Income	0.000114	0.000013****	8.79	0.001
HHSize	−0.0051189	0.0051791^{NS}	−0.99	0.323
BeEight	0.0184789	0.0098732*	1.87	0.061
Hphour	0.023367	0.0156369^{NS}	1.49	0.135
MonEExp	0.0391865	0.0084662****	4.63	0.001
Constant	2.702091	0.0768308	35.17	0.001
Number of obs	324			
Log likelihood	−1320.1297			
LR Ch^2	389.92			
Prob > Chi^2	0.0000			
Pseudo R^2	0.1287			

NB, Significant levels; NS, Not significant

*P < 0.1(10%); **P < 0.05(5%); ***P < 0.01(1%); ****P < 0.001(0.1%)

From the model (Table 6), households' income has a significant ($P < 0.001$) impact on the consumption of electricity in Ghana. This implies that in order for a particular household to choose any electronic appliance, monthly income should be a determining factor [82, 83].

4.5 Marital status

The marital status of household heads from the model (Table 6), was significant and relates negatively (P = −0.052) with the choice of energy-efficient appliances by households. It is assumed that with higher household expenditure levels,

Table 7 Energy saving practices among households. *Source*: Based on field data, 2021

Electrical gadgets/household (%)	Practice: rate at which electrical gadgets are switched off when not in use (%)		
N = 396	Always	Sometimes	Rarely
TV (84.8)	29.80	61.60	8.60
Light bulb (98.2)	33.90	63.50	2.60
Fridge/freezer (55.3)	40.60	35.20	24.2
Fan (79.8)	38.60%	46.80%	14.60%

Table 8 Households perceived meaning of energy conservation. *Source*: Based on field data, 2021

Energy conservation response	Frequency	Percentage
Don't Know	187	47.3
Using available energy judiciously	117	29.5
Using energy only when needed	91	23.0
Keeping energy without using it	1	0.3

they would be able to conserve electricity by choosing energy-efficient appliances. This is collaborated by Frederiks, Stenner and Hobman [83] who posit that marital status has a significant effect on energy conservation behaviours of households whose effect is expected to manifest in electricity cost reduction, savings to households' income and climate change mitigation [84, 85].

4.6 Years of residency

From Table 6, the relationship between years of residence and the choice of energy-efficient appliance was positive and significant ($P < 0.05$). It suggests that the longer households stay in one abode for a longer period, there is more likelihood for such households to purchase or use energy-efficient appliances [86]. Literature also suggests that the older the residence of a consumer, the more likely that household will engage in energy conservation practices [65, 67]. Homeowners residing in the older dwelling may tend to adopt greater conservation measures than those residing in newer dwellings [87], especially if older dwellings are in poor conditions and requires the installation of new appliances [57].

4.7 Energy saving practices

The study analysed the energy-saving practices of respondents on selected household gadgets. The main consideration was the frequency at which electrical appliances are used in the metropolis. Respondents were asked to indicate the rate at which they '*Always*', '*Sometimes*' and '*Rarely*' switch off their electrical appliances to conserve energy when not in use. In terms of switching off the electrical appliance when not in use (energy saving practice), cumulative responses on energy saving practices show that '*Sometimes*' and '*Rarely*' rated the highest across all levels of income brackets and for all the gadgets listed in Table 7. Less than half of households who owned TVs (29.80%), light bulbs (33.90%), fridges/freezers (40.60%) and fans (38.60%) always switch off their appliances when not in use. This may support the assertion that the energy regulatory body (ECG) in the Cape Coast metropolis has been embarking on some form of energy literacy education.

Ethics on conservation practices were also cited in brochures of the regulatory agencies for educational purposes. These efforts, however, need to be intensified.

4.8 Energy conservation awareness

To ascertain the level of awareness of households on what energy conservation is, respondents were asked to further explain what they perceived energy conservation to mean (Table 8). Returned responses indicate that households in the Cape Coast Metropolis, to some extent, have some level of knowledge of what energy conservation is. However, the number of those who '*Don't know*' is equally worrying. This may be attributed, to not only inadequate energy conservation or savings campaigns in the metropolis but also to the way and manner it is effectively communicated to households.

An increase in public knowledge, using the right terms, language and medium to understand energy conservation ethics will improve energy-saving practices among households. As opined by Nunoo [88] and Amos-Abanyie et al. [36] consumers put up wasteful practices due to a lack of knowledge or awareness of the use of energy and its related negative implications. Poortinga et al. [52], Wang et al. [53] and Kumi [69] collaborate on this assertion as they scientifically prove that consumer education has a significant level of influence on energy-saving practice.

4.9 Energy efficiency label

The level of households' awareness of the use of energy efficiency labels was assessed. Figure 5 depicts returned responses with less than half of the respondents (40%) having informed knowledge of what energy efficiency labels are. This suggests that the majority of households (60%) may not be using energy-efficient electrical appliances or even check for energy efficiency labels on appliances they purchased, although, these labels on electrical appliances have the possibility of driving the success of households' conservation and efficiency programs [89].[1]

5 Conclusion and recommendations

This study assessed energy conservation and efficiency awareness practices of households in the Cape Coast Metropolis. The level and variability in energy conservation practices and the level of energy-savings awareness education among households were examined. From the findings and accompanying discussions, it can be concluded that the level of energy conservation awareness among households is low. Although some households were able to explain what energy conservation is, the majority did not know about it, attributed not only to inadequate energy conservation or savings campaigns in the metropolis but also to the way and manner these are effectively communicated to households. However,to strengthen, energy conservation awareness in the metropolis proactive campaign and education is required at all levels of the social strata. An educational policy could be tailored to target the curriculum at the formative stages in our schools to impact energy-saving or conservation behaviour in the youth. This is apparent in the study as highly educated households or individuals were more inclined to adopt energy conservation or saving behaviour. Moreover, an increase in public knowledge, using the right terms, language and medium to understand energy conservation ethics will improve energy-saving practices among households. To achieve the expected outcomes, energy conservation awareness campaigns should be intensified. It was evident that a relatively low proportion of the households had informed knowledge of what energy efficiency labels are or even check for energy efficiency labels. This has serious policy implications for the purchase of energy-efficient domestic electrical appliances by households. In addition, there is an indication that the majority of household-owned fridges (or freezers) most of them are not eco-labelled. These are imported second-hand electrical fridges with high-energy consumption. This calls for the continuous enforcement of the ban on the importation of second-hand electrical appliances, particularly fridges (or freezers) into the country. The Energy Commission (EG) of Ghana's policy on the exchange of old energy-inefficient fridges for new efficient ones need to be up-scaled to remove the existence of old fridges from the system. The retailing arm of electric power distribution in the country, the Electricity Company of Ghana (ECG) and the energy policy-marker, the Energy Commission as a matter of urgency should embark on continuous education, sensitization workshops and campaign of the populace on the implications and meaning of eco-labelling and the use of star rating systems on electrical appliances in the country.

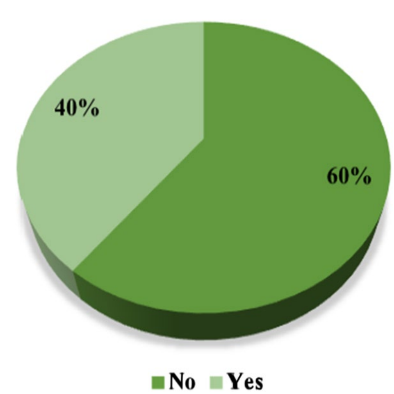

Fig. 5 Energy efficiency label. *Source*: Based on field data, 2021

As a policy, periodic re-wiring of older dwellings or buildings should be encouraged. This was evident from the study that those residing in newer dwellings have low energy consumption levels as compared to older dwellings with poor environmental conditions and requires the installation of new appliances. The study also showed that concerning the household choice of energy-efficient appliances, some socio-demographic factors directly influence the household decisions to purchase an energy-efficient appliance.

The number of years spent in school by household heads, income levels, expenditure, and age of households were key factors influencing an individual's choice of energy-efficient appliances. There was significant variability between existing social strata, in terms of income and use of electrical appliances among households. To address the positive relationship between energy conservation behaviour and income, market-based policy instruments could be designed to target high-end electricity consumption households or individuals to pay more for electricity in the form of high tariffs. Nevertheless, based on the findings, this study recommends energy literacy to improve households' energy efficiency practices and to ensure energy cost savings, environmental protection, climate change mitigation and the drive towards achieving Sustainable Development Goal Seven (SDG 7). To be led by authorities of the municipality and in collaboration with the electricity distribution company, Ghana Education Service and the National Commission on Civic Education (NCCE), education campaigns on energy conservation could be integrated into the municipality's routine community durbars through radio, television and the social media (Twitter, Instagram, Facebook) channels. These programmes could be intensified until households become more conversant with conservation practices.

5.1 Limitations of the study

This research is a cross-sectional study, a snapshot of events within a short period within the Cape Coast metropolis. Though the University of Cape Coast, a high-energy consumer falls within the metropolis, it was not included in the study but considered an outlier. Future studies may explore longitudinal research with much focus on communities' income strata across the country.

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Author contributions The research topic was formulated by ANAB and revised by JAD. The field data collection instruments were designed by ANAB and JAD. GAB, EA, ET, and JKN participated in the data collection. Data cleaning prepared Figs. 1, 2, 3, 4, 5, Tables 1, 2, 3, 4, 5, 6, 7, 8, and an internal assessment of the final draft was done by EKN, ET, and SM. All authors edited the first draft to produce the final version of the manuscript. All authors read and approved the final manuscript.

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Data availability Data will be available from the corresponding author upon reasonable request and respondents' permission.

Declarations

Ethics approval and consent to participate Approval was obtained from the ethics committee (the Institutional Review Board-IRB) of the University of Cape Coast. The procedures used in this study adhere to the tenets of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All respondents agreed for their data to be used anonymously for the purposes of research.

Competing interests The authors declare that they have no competing interests.

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