The dynamics of households' adoption behaviour of solar home systems (SHSS) in Ashongman Estate in the Greater Accra Region of Ghana

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Abstract

Ghana heavily relies on hydrogenated and thermal electricity. For the past thirteen years, the dynamics of climate change and increasing fuel prices have engendered an electricity crisis since the supply of electricity cannot match the ever-burgeoning demand from households and industries. While this is so, the uptake of renewable energy sources has been abysmal in Ghana. This study thus seeks to assess the adoption behaviour of solar home systems, an environmentally friendly and convenient alternative electricity source by households in Ashongman Estate, a suburb of Accra, Ghana. Using a mixed research approach including binary logistic regression analysis, the study found that education, income levels, the performance expectation and housing tenure arrangements were crucial factors that determine the willingness of households to adopt the solar energy sources. We recommend that to encourage the uptake of Solar Home Systems (SHSs) which are environmentally sustainable, it is expedient that government collaborates with relevant stakeholders to provide solar home systems (SHSs)for households with the necessary technical capacity while putting financial policy measures in place to ensure their affordability regardless of socio-economic status. In addition, we recommend further studies to explore the role of incentives in solar home systems adoption to inform policies that will encourage their uptake.

Keywords: Solar Home Systems (SHSs), Diffusion of Innovation Theory, Households, Adoption, Renewable Energy, Sustainable Energy

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Introduction

The socio-economic development and survival of individuals and society largely hinge on the availability of energy (Agyekum et al., 2020). Despite this assertion, majority of the world's population does not have access to electricity, with the situation being more profound in the case of Africa where an estimated 635 million are without electricity (Metayer et al., 2015). The energy demand of households forms a crucial component of the complete energy demand of nations, which shapes the paradigms of energy systems (Grunewald et al., 2012). A significant constraint in the supply of electricity has been its unreliability (Taale & Kyeremeh, 2016). Parallel to the assertion of the lack of electricity in Africa, most households have been heavily reliant on energy sources such as cow dung, firewood, charcoal, and palm kernel among others, which have been identified to have adverse impacts on human health, and the environment because they trigger deforestation and the greenhouse emissions (Sovacool, 2012). Illustrating the environmental impacts of using fossil fuel in energy production, Qu et al. (2013) note that the emission of carbon dioxide is accelerating, and the continuous use of fossil fuel has led to an increase in the earth's average temperature by 0.76 degrees Celsius. The advent of harnessed energy has been closely associated with economic growth and prosperity of nations, which in turn provides comfort for living. As will be expected, the associated economic benefits of energy forms have been on the ascendency over the years and have further been exacerbated by the dynamics of population growth, urbanisation and rapid industrialization (Filippini & Hunt, 2011). In a similar dimension, Kumar et al. (2015) highlight that the provision of surplus energy is essential for the achievement of the development agenda of developing nations. While the accompanying benefits of energy remain desirous, a major source of concern to energy experts and users has been the supply of clean and reliable energy (UN, 1991) especially when current energy systems are unsustainable in the face of environmental, climate and human health impacts. Again, the synergistic impact of energy, and in particular, renewable energy on achieving many Sustainable Development Goals make it desirous and expectedly has formed the core of many international agendas (Schwerhoff & Sy, 2016).

Many governments of developing countries face the challenging task of providing electricity for household consumption and meeting the industrial demand for electricity. This is a challenge given that industrial activities form the bedrock of their economic prosperity. The situation is more precarious in the case of developing countries with wide energy access inequality gaps (Kapadia, 2004). Currently, available energy pathways for energy provision are heavily dependent on fossil fuel and hydro-generated energy, which are associated with

huge financial commitments connected to the construction and maintenance of the facilities and equipment used in the energy generation. This makes them financially unsustainable.

Finding a way out, solar home systems have been advanced as environmentally friendly and cost-effective options to energy provision (Ashnani et al., 2014: Kruzner et al., 2013). The several advantages associated with solar energy include the reduction in greenhouse gas emissions, energy sovereignty and increased energy supply (Heng et al., 2020). Again, solar home systems have been touted as being reliable (Worku et al., 2018), reduce poverty, provide comfort, improve quality of life and ensure the posterity of businesses, especially small and medium scale enterprises (Azimoh et al., 2015: Javadi et al., 2013). The associated benefits have seen estimations by the International Energy Agency which suggest that solar energy will be the largest source of electricity by the year 2050 (IEA, 2014). Despite projections that solar energy will be the paramount source of electricity less than three decades from now, the current, the coverage of SHSs adoption, especially in developing countries leave much to be desired.

While the energy-economic growth nexus has been confirmed and proven in the case of many countries (Agyeman et al., 2020: Yankson et al., 2018), the supply of energy in Ghana which has predominantly been hydro-generated electricity has not been able to keep up with continued demand growth (World Bank, 2013). In the face of the growing electricity demand, thermal plants have been incorporated into the national grid to meet demand (USAID, 2020: Mensah et al., 2019) but these efforts have left much to be desired. The results have been erratic power outages and load shedding (Gyamfi et al. 2015). As will be expected, this demand and supply mismatch has evolved into an energy crisis that has had precarious effects on business' revenue and implicitly, economic growth. Hydropower generation stations in Ghana, which heavily relies on rainfall have not been able to operate at full capacity. This is because of the dynamics of climate change, which has seen a reduction in rainfall (Gyamfi et al., 2018). Consequently, Ghana has had to rationing electricity supply at certain points in time over the past three decades while hiring electricity generation equipment from other countries. These periods are 1983-1984, 1997-1998, 2003 and 2006-2007 (Merem et al., 2018).

Environmental sustainability, as well as the depletion of non-renewable energy sources (Okoro & Madueme, 2007) concerns about clean energy sources, have seen the advancement of solar energy sources and other renewable options as better alternatives and this has been projected within the energy ladder theory. The energy ladder theory advances that modern energy sources are crucial to social and economic development through the eradication of the associated negative effects such as environmental degradation and health challenges associated

with the use of traditional energy sources that are also unclean (Van Der Kroon et al., 2012). In Ghana, studies by Asumadu-Sarkodie and Owusu (2016) found that the inability of the country's electricity production to keep up with demand in the light of achieving sustainable development targets calls for the harnessing of the vast and inexhaustible solar energy potential.

What this article sets to achieve is to assess the extent to which urban households in Ghana are willing to adopt solar energy and the barriers in doing so, using a case study of a selected suburb in the national capital. The work also proposes policy recommendations that are expedient for the adoption and sustained use of renewable energy sources, which furthermore underpin social, economic, and human development. The remaining sections of this detail the review of literature, the theoretical framework of this study, the methodology, results, discussion, and conclusion.

Ghana's Electricity Situation

Ghana's population as of 2018 was 29.77 million (World Bank, 2018). Based on the annual growth projection of 2.2% by the World Bank (2018), this figure should presently be circa 30 million. Ghana is a lower-middle-income country (Boachie et al., 2020; OECD, 2020) and has a large informal economy (Ocran, 2018: Osei-Boateng, 2011) with 83% of the private sector workers belonging to the informal sector (GSS, 2014). The production and supply of electricity in Ghana are from three sources: hydro, thermal and solar. Currently, Ghana has an energy generation capacity of 4000 MW although the real generation hardly transcends 2,400MW (USAID, 2020). Hydroelectricity, thermal (depending on fossil fuel) and renewable are the only sources of energy in Ghana. These have generation capacities of 1580MW, 2796MW and 22.5MW respectively (USAID, 2020). With energy demand doubling over the years in the face of these supply sources, more is desired in the provision of energy for household and industrial uses. The energy generation capacity in, based on a 2020 report by the Energy Commission is presented in figure 1 below.

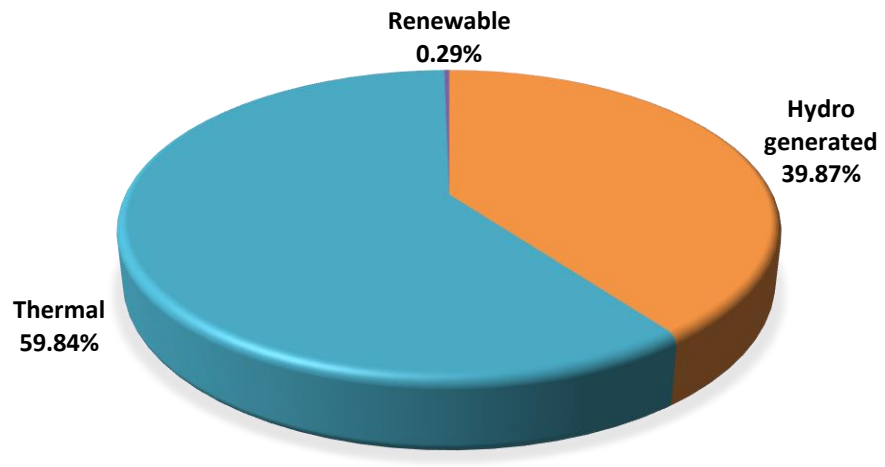

Figure 1: Electricity Generation Capacity in Ghana
Source: Energy Commission Ghana (2020)

Ghana's over-dependence on hydrogenated electricity and thermal has not been financially feasible for constant production and supply of energy to households and businesses. Ghana's energy provision is highly slanted towards hydrogenated electricity from her three dams: Akosombo, Bui and Akuse (Yankson et al., 2018). This over-reliance coupled with the unfavourable dynamics of rainfall manifesting in rainfall shortages has had a devastating impact on their operation and production capacity. Similarly, in the case of thermal generated electricity which depends on fossil fuel, the invisible forces of market dynamics at times fix fuel prices at high levels which influences purchasing power and in turn, production capacity (Zameer and Wang, 2018). On the demand side of electricity in Ghana, households and businesses have been the main users and many economic activities including industrial and home-based enterprises (HBE) are heavily reliant on electricity for their activities. The outcome of this has been production below capacity levels and loss of working hours due to inactivity whenever there is no access to electricity.

Despite this growing trend of dependence on electricity produced from fossil fuels and hydrogenation facilities, a comparative view of production and consumption trends indicate that Ghana is an energy-poor country (Adaramola et al., 2014) as electricity supply has never been commensurate with electricity demand. In the year 2012 for instance, the amount of electricity generated in Ghana was 2280MW whereas consumption was 9258 GWh, with residential consumption accounting for 32 per cent (Ghana Energy Commission, 2012). Worse

yet, the Ghana Energy Commission (2016) notes that the demand for electricity over the years has been increasing at an annual rate of 10 per cent. Noting that the production capacity of Ghana's power plants is disproportionate to this demand, Asante (2007) identifies fuel supply challenges in the case of thermal power plants due to increased oil prices and irregular rainfall patterns for hydro plants as the causes. The challenge remains how this ever-growing demand epitome can be met.

About 82% of Ghana's population has access to electricity; with a 67% rural coverage and a 94% urban coverage, which makes it the second-best electrified economy after South Africa in the subregion (World Bank, 2019). In the recent past decades, however, Ghana has been through three major power crises; the first in 1983, second from 1997 to 1998 and more recently, from 2012 to 2016. This consequently led to an unprecedented era of tottering electricity supply which was named 'dumsor' to wit 'on and off', describing the pattern of electricity supply. The electricity crisis has only been stabilized through the installation of emergency power plants by the government (Ahiataku-Togobo, 2014). Ghana for the past decade or so has been plagued with severe electricity supply challenges stemming from overreliance on hydrogenated and thermal energy sources, which has further been complicated by the dearth of effective structures to recoup electricity production and distribution costs (Kumi, 2017). As a panacea, power prorating has been adopted over the years in the supply of electricity, which has resulted in redundancy, low quality of social life and abysmal turnover for many enterprises (Eshun & Tuffour, 2016). The impact of this has been the loss of productivity amounting to an estimated daily loss of 2.1 million US dollars (Kumi, 2017) and an approximated annual loss of 320 million US dollars to 924 million US dollars (ISSER, 2014). Putting this in a more neoteric context, Ghana's economy was one of those in West Africa that experienced significant growth in the year 2012; economic growth was pegged at 8.2%. During this period, Ghana was ranked the fourth topmost investment destination in Africa, per the African Business Panel Survey (Kuada, 2015). Subsequent years after this observed an undeviating decline in economic growth with 2016 approximations narrowly reaching 3.3%, a situation partly caused by Ghana's energy crises (African Development Bank, 2017). As well, Eshun & Amoako-Tuffour (2016) suggest that the dependence on electrcity generated from hydro and thermal sources, whose management is in the hands of a selected few industry players is not ample to address the current electricity challenges the country is faced with. Buttressing this, Kumi (2017) identified unsatisfactory management, distribution losses, ineffective tariff structures and non-payment of bills as bulwarks to improving the electricity sector.

It is now apt for government and relevant stakeholders to propagate the adoption of renewable energy sources to reduce the use of conventional electricity sources while fostering economic activities for economic growth. Furthermore, Kuada and Mensah (2020) note that the trend of electricity supply in Ghana using conventional means has provided a market prospect for solar energy alternatives. More importantly, the authors note that there has been a proliferation in the number of businesses in photovoltaic systems provision and installation. In this regard, an understanding of households' perceptions about solar home systems will capacitate their design, provision and financialization for households.

Solar Energy-A Renewable Alternative

Solar energy is considered the world's most abundant energy form and source, which is corroborated by the constant emission of solar energy from the sun all year round (Păceşilă, 2015). While making this claim, it is expedient mentioning that many factors including geography, climate, building density and much more influence the intensity of solar energy in an enclave. A unique advantage of solar energy is its transmogrification to various energy forms to meet household demand as a modern and clean energy form (Zamfir, 2014). While this is so, Pinner and Rogers (2015) note that the uptake of solar energy has been unhurried. In contrast to this, many studies have posited that the world's current solar energy is enough to provide electricity for the whole world despite variations in production potentials (Johanson et al., 2004) Within the African domain, solar energy is now gaining prominence as a market commodity rather than a product of donor projects (Mutua and Kimuyu, 2015).

Two types of solar technology harness the radiation from the sun for household energy provision. These are the photovoltaic technology, which captures solar energy for household electricity, and the solar thermal technology, which harnesses solar energy for home heating purposes (U.S Census Bureau, 2007: Schelly, 2010).

Ghana has high potentials for harnessing solar energy for the provision of electricity (Deichmann et al., 2011: Zhang et al., 2018) which spread across the country. Quotidian estimations of solar radiance in Ghana range between 4 kWh/m2 to 6 kWh/m2 with annual sunshine estimations between 1800 to 3000 hours which is a great source of electricity (Energy Commission, 2011).

Over time, the increasing cost of electricity production using conventional means has seen the proposal and adoption of renewable energy sources, which are economically efficient (Agyekum et al., 2020). One of such energy provision channels is solar energy.

Currently, in Ghana, plans have been underway to encourage the adoption of renewable energy sources (Agyekum et al., 2020). In achieving this, the Ministry of Energy and Power, Ghana has distributed close to 15000 solar systems in rural regions which have a combined energy production capacity of 3.2MW (Gauri et al., 2015). This initiative is in place, as most rural areas in Ghana have not been electrified; less than 50% rural average relative to 75% national coverage (Kwakwa et al., 2018)). More recently, data from the World Bank's website indicates that 67.35% of Ghana's rural population have access to electricity while the natural electricity coverage was 82.39% (World Bank, 2019). In addition, the Volta River Authority (VRA) in 2013 through donor funding commissioned a Solar Power Plant (SPP) to generate 2.5MW of electricity, which was incorporated into the national electricity grid at Navrongo (Gauri et al., 2015). Again, there are plans in the pipeline to harness the solar energy capacity of the country. Retrospective analysis of the success of plans to add to electricity production using renewable energy sources did not materialize. For example, the Ghana National Energy policy in 2010 set out to achieve a renewable energy electricity mix of 10 per cent but seven years later in 2017, only 0.7 per cent has been achieved (Sakah et al., 2017; Energy Commission, 2011). Considering the increasing demand for electricity in Ghana and the production capacity of the various sources, it is conspicuous that the renewable energy sector remains underdeveloped.
Within the solar energy domain, solar home systems (SHSs) have gained prominence as a preferred technology, which has manifested in the steady and sustained growth in its adoption and installation over the years (REN21, 2018). The case for this energy provision technology has further gained notability as national governments, international organizations, NGOs and other relevant stakeholders are racing to ensure ecological environments and low carbon emission thus it being advanced as environmentally friendly and has culminated impact of overall wellbeing and quality of life of its users.

Renewable Energy Potential and Legislation in Ghana

Akin to several African countries, Ghana is endowed with renewable energy, which includes hydro, wind, solar, and wave energy that can be explored for electricity generation (Energy Commission, 2018). Located in the tropics with sufficient radiation, Ghana receives approximately 4.0-6.5 kWh/m2 of solar radiation daily and 1800-3000 hours sunshine duration annually. This is more profound in the northern part of the country. The solar radiation potential of the country is estimated to be circa 35 EJ (Exajoules) (Gauri et al., 2015).

Having noticed the energy challenges confronting the country, the government of Ghana in 2011 enacted the Renewable Energy Act 2011 (Act 832) which seeks to regulate the licensing and activities with the renewable energy sector through the Energy Commission. Among the objectives of the legislation are the promotion, development, and utilization of renewable energy sources for electricity production and the encouragement of households and businesses to adopt renewable energy sources for electricity generation to achieve diversification while ensuring a reliable supply of electricity, which in effect will widen the access net. While this legislation provides an optimistic renewable energy framework, the question remains, as to what extent this has been implemented, considering the abysmal electricity generation capacity of renewable energy sources in Ghana.

Prior this, the foremost policies on solar renewable energy in Ghana can be traced to 1983 when the National Energy Board (NEB) was first established, and the first solar energy project was implemented in the early 1990s, which saw the installation of 335 solar photovoltaic systems which generated an estimated power of 160kW (IEA, 1991). Solar energy provision under this initiative however was limited to rural areas, which were not included in the national grid (World Bank, 2003). According to Abavana (2000), the main stakeholders in this project were communities, private-sector personnel, financial institutions, government, and development partners.

Partnership with development agencies has been intrinsic to Ghana's solar electrification journey. From 1992 to date, Ghana has collaborated with several donor agencies to implement solar electrification initiatives (Energy Commission, 2005). Some of these agencies include German Technical Cooperation (GTZ), the United Nations Development Programme / Global Environment Facility (UNDP/GEF) and Danish International Development Agency (DANIDA). Such partnerships have made the installation of over 22,536 solar systems since 2009 (Obeng and Evers, 2009). Some of the solar systems and purposes include Home solar systems design to support basic household needs such as lighting, radio and television; Hospital systems for vaccine refrigeration and lighting; Public space solar systems for lighting public spaces such as market, lorry stations, streets for visibility and solar water pumping systems for drinking water provision (Ghana Energy Commission, 2013).

Theoretical Framework: Diffusion of Innovation Theory

This study seeks to assess the adoption behaviour of households in the study area regarding solar home systems. This study therefore leans towards a psychological understanding of

human behavior and decision making which is a complex network (Alipour et al., 2021). Consequently, the study is designed within the theoretical framework of diffusion of innovation (Rogers, 2003). The theory of diffusion of innovation investigates the decision-making process of people towards a novel idea that is spreading or being accepted by people in a social system (Rogers, 2003). Defining innovation, Rogers (1976) notes that it is an idea that society are unfamiliar with. Solar home systems adoption when there are conventional energy sources is a socially oriented process just as the diffusion of innovation theory posits and is highly influenced by the perceptions of people (UNEP, 2013). In the context of this study, solar home systems are considered an innovation in Ghana due to their recent emergence. This study considers the nexus of factors that inform the adoptive behaviour of people towards solar home systems (SHSs) within this theoretical framework.

Research Setting and Methodology

This study adopts a cross-sectional research design to achieve the set objectives of the study. Allen (2007) notes that cross-sectional research designs are adopted to obtain empirical data from a defined population at a point in time. The dearth of secondary data at the micro-level on household energy trends necessitates the adoption of primary research. To achieve the research objectives, we adopted a mixed research method (Bhattacherjee, 2012) which allowed for the use of both qualitative and quantitative techniques. The research instruments for data collection were a carefully designed survey questionnaire with open and close-ended questions. The questionnaire for the survey was divided in to three sections. The first section aimed at obtaining data on the socio-economic characteristics of respondents, which included their sex, marital status, employment status, level of education and income levels. The second section sought to gather information on the electricity usage pattern of respondents. Questions in this section asked about the monthly cost of electricity to households, the electrical gadgets and appliances used, and the regularity of electricity access. The third section sort to gather data on the willingness of households to adopt solar home systems (SHSs). Additionally, a section was provided for respondents to provide further information that informed the willingness to adopt or otherwise. This allowed assessing the perceptions of households about SHSs and what factors shaped such perceptions.

Accra, the capital of Ghana was chosen as the case study for this paper. This choice of case study is justified by the fact that this urban landscape has the highest electricity consumption rate in Ghana. This is partly because it is the capital of Ghana and the industrial hub of the

nation. It therefore accommodates most of the country's industry as well as the residential units hence accounting for a significant share of the energy demand. Using a multistage sampling approach, Ga East municipal was selected with the study based in Ashongman Estate one of the suburbs in the municipality (AMA, 2011). The sampling process of arriving at this case study began with sampling from all the 16 districts in the Greater Accra region. The Ga East Municipal district was chosen before the case study was sampled.

Respondents in the study were randomly selected in the study area. The respondents were conveniently sampled (Galloway, 2005) mainly due to the uncomplicated nature of this sampling approach and its cost-efficiency. The researchers went around the community seeking the consent of households to partake in the research. The researchers chose to collect data only on weekends, as this was when most households were readily available. With this approach, the authors admit that households, which may offer relevant information and may have adopted solar home systems, may have been missed.

The questionnaires were self-administered by the researchers and recruited field assistants who were taken in cases where the respondents were not conversant with or fluent in the English Language, the questions were translated in the local dialect, mainly Akan, Ewe and Ga and the responses later transcribed. The results from the survey were analyzed using both quantitative and qualitative methods. Adopting qualitative analysis, we employed content analysis, which is the systematic analysis of a text. Using the responses from the self-administered questionnaire, we examined the content of all the responses to the open-ended questions to identify variables that influence the preferences of households towards solar energy technologies in the study area. The research design process is presented in Figure 2 below.

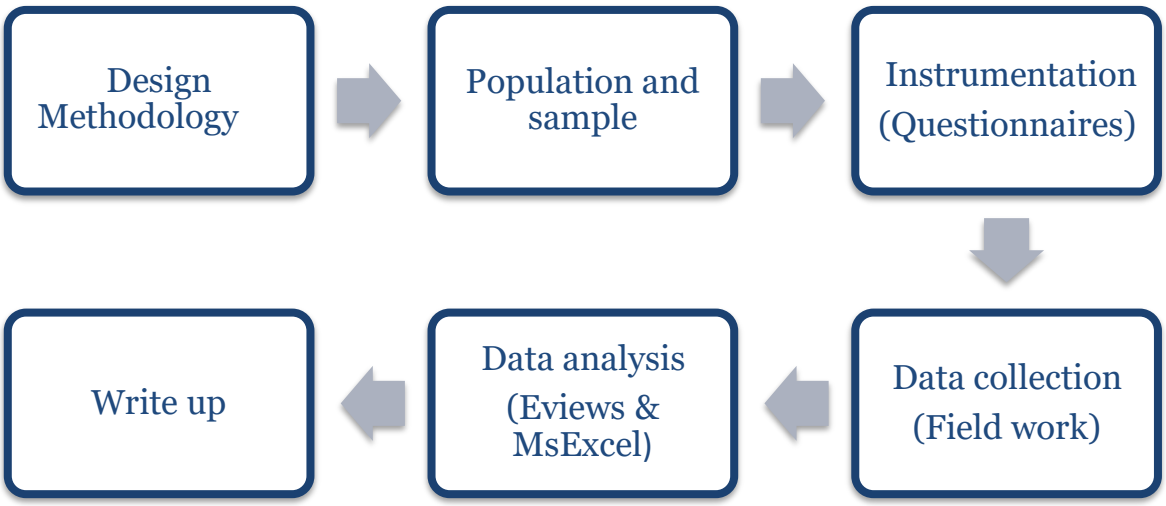

Figure 2: Research Design Process
Authors' construct, 2020

Sample Size

In arriving at the sample size from the population, random sampling was used based on a household population of 2, 209 (GSS, 2012) for the case study.

$$SS=\frac{Z^2*(p)*(1-p)}{c^2}$$

Where: Z= z value (confidence level) which in this case is 95%, p= percentage picking a choice which is 0.5 and c= confidence interval which is 1.960. Substituting the values in the formula, the sample size arrived at was 1173 households, which confirms validity credibility of our findings. However, this number was rounded to 1200 households for the study. The sampling method, considering the confidence level, determines the extent of generalization of the findings of this study.

Data Analysis

Bucur et al. (2017) suggest that one of the commonly used statistical methods to assess the nexus between one or several variables and another dependent variable is regression. The choice of regressions, whether linear, nonlinear, simple, or multiple is determined by the genre of variables in the study. This study assesses the willingness of households to adopt solar home systems: implicitly the outcome will be the willingness to or otherwise which are shaped by several variables. In the context of this study where the dependent variable is dichotomous,

binary logistic regression is the most appropriate approach for investigating the link between willingness to adopt and the other variables in this study.

In this study, the authors specify the binary logistic regression model as

$$\boldsymbol{Logit}\left[\frac{\boldsymbol{P(Y=1)}}{\boldsymbol{1-P(Y=1)}}\right] = \left(\frac{\boldsymbol{\pi}}{\boldsymbol{1-\pi}}\right) = \boldsymbol{\alpha} + \boldsymbol{\beta_1 x_1} + \boldsymbol{\beta_2 x_2} + \ldots\ldots\ldots + \boldsymbol{\beta_k x_k}, \boldsymbol{0 \leq \pi \leq 1} \quad (\boldsymbol{1})$$

This is restated as

$$\boldsymbol{logit(\pi)} = \boldsymbol{\alpha} + \boldsymbol{\beta_1 x_1} + \boldsymbol{\beta_2 x_2} + \ldots\ldots\ldots + \boldsymbol{\beta_k x_k} \quad \textbf{(2)}$$

From the above equations $\boldsymbol{\alpha}$ represents the constant term, $\boldsymbol{\beta_1, \beta_2}$ ... ... $\boldsymbol{\beta_k}$ are regressor parameters and $\boldsymbol{x_1, x_2}$ ... $\boldsymbol{x_k}$ are the explanatory variables and $\boldsymbol{\pi}$ represents the probability of success.

Results and Discussions

Demographics and Socio-economic Characteristics of Respondents

Of the 1200 respondents who were household heads, 826 of them representing 69% of the sampled respondents were male while the remaining 374 were females and represented 31% of the respondents. The dominance of male-headed in this case is a paradigm that is deeply rooted in the Ghana culture as men are expected to be responsible for their families (Kpoor, 2019). Fifty-two per cent (52 %) of the respondents were tenants while the remaining 577 representing 48% of the respondents were property owners occupying their own houses. This reflects the dominance of the rental housing market in the country as private housing provision by individuals has been arduous in the previous decades due to the dynamics of neoliberalism and globalisation (Asante et al., 2015). Two main housing arrangements were identified which are compound houses, housing multiple households which are either related or otherwise and self-contained houses which have single households. These housing paradigms are the most prominent in Ghana with the compound houses constituting most of the housing stock.

Table 2: Educational Level of Respondents

Educational Level	Number of Respondents	Percentage
Attained no formal education	144	12
Attained Primary/ JHS level education	329	27.4
Attained SHS level education	405	33.75
Attained tertiary level education	322	26.8

Source: Authors' construct 2020

Results on the educational level of respondents are presented in Table 1 and further discussed in this section. Regarding educational attainment, 12% of the respondents had no formal education while the outstanding 88% had formal education. The educational levels varied from the Primary School, Junior

Secondary School, Senior Secondary School to the University levels. Again, many of the respondents who had attained the highest level of education were those employed in the formal sector in positions as doctors, teachers, lecturers, lawyers, and nurses, among others.

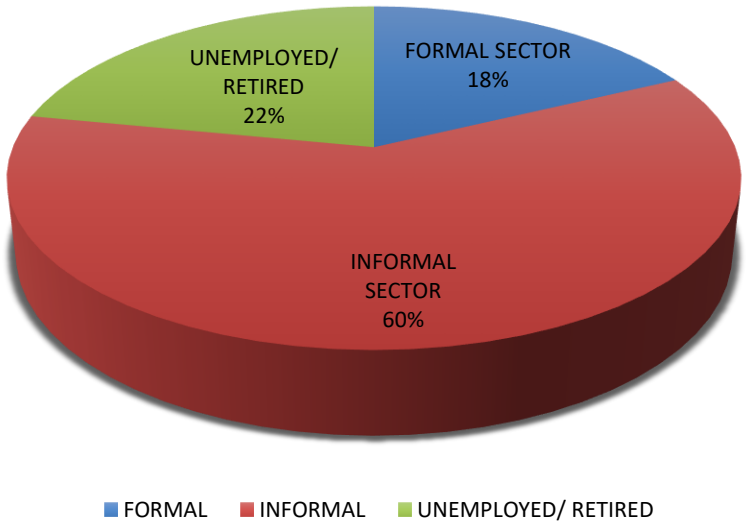

Figure 3: Occupation Sector of Respondents
Source: Authors' construct, 2020

Results on the occupation sector of respondents are presented in Figure 3 above. Most of the respondents, 937 accounting for 78%, gainfully employed in the formal and informal markets while the remaining 22% representing 263 respondents were either unemployed or retired. The case of unemployment stemmed from either ill health, loss of jobs or inability to access gainful employment.

Income wise, 984 representing 82% of the respondents earned between GH₵ 1001 to GH₵ 2000, which according to GSS (2008) reflects the turnover of the middle-income class in Ghana. Only 60 respondents who accounted for 5% of the sample size earned above GH₵ 2000 hence are classified as upper-income earners (GLSS, 2008) and while the remaining 13% earned below GH₵1000.

Willingness to Adopt Solar Energy

As earlier indicated in the methodology section, robust statistical analyses were adopted to unravel the relationship between the willingness of households to adopt solar panel systems. Table 2 presents the output of our analyses, which is further explained.

Table 2: Binary Logistic Regression Results

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.090830	0.066621	16.37372	0.0000
Male	0.658590	0.390827	1.685119	0.0920
Education	0.301388	0.300043	-1.004481	0.3151
Income_Range	0.839905	0.215717	3.893560	0.0001
Property_Ownership	-0.351010	0.166932	-2.102718	0.0355
Power_Outage_Experiences	0.013958	0.203200	0.068691	0.9452

From the table above, gender, education, income, and power outage frequency exert a positive influence on the willingness of households to adopt solar panel systems.

While governments, energy policymakers and think tanks, are heralding the adoption of renewable energy sources, it is of utmost importance to identify and understand various elements that are likely to influence the decision to or not to adopt renewable energy forms such as the solar energy, which is the focus of this current paper. Overall, we found that 75% of the respondents were willing to adopt solar energy while the remaining 25% were unwilling. The major factors influencing the decision to adopt solar energy is the reliability of energy supply while for some, it is the affordability of the solar system and not paying monthly electricity tariffs once it is installed. In another vein, many respondents were comfortable with paying occasional maintenance fees for solar electricity systems than paying monthly electricity tariffs.

Access to electricity is very essential for the proper functioning of households hence questions were asked regarding access to electricity, expenses of households on electricity and consistency of supply. All the respondents had access to electricity through the national grid with a handful of them, 23 respondents representing 2% possessing stand by generators powered by diesel/petrol, which they use in the event of power outages. This finding corroborates the USAID's 2020 report on electricity connection rate in Ghana, which states that 91% of urban households have access to electricity. None of the households had Solar Photovoltaic systems sources of electricity. This finding also highlights the dearth of solar energy initiatives for urban households is because almost all the solar electrification initiatives have focused either on public spaces, hospitals, or rural areas.

The main use of electricity among the respondents was for lighting and for the use of basic electrical appliances like television, radio, refrigerators, microwaves and washing machine.

Thus, enforcing the view that constant electricity supply is essential for the effective running of households. On how much of monthly income is expended on electricity, 159 respondents, representative of 13% indicated that they spent between GH₵ 50 to GH₵ 100. This group of respondents were those who did not use any high voltage electrical appliances such as microwaves, electric ovens, among others. For 723 respondents who represent 60% of the sample size, they spent between GH₵ 100 to GH₵ 200 while the outstanding 27% (318 respondents) spent above GH₵ 200. Household income levels were influential in the willingness of the respondents to adopt solar home systems for their households. From the regression analysis, it was found that for every unit increase in income, the log of odd ratio implies positive influence on the dependent variable and is significant at all levels of significance. Accordingly, majority of the respondents earning below GH₵ 500 were unwilling to switch from the national grid or add solar photovoltaic systems as a complementary electricity source. This perspective is partly shaped by the perception that solar home systems are sophisticated technology that only the rich can afford. In contrast to this observation, those with more income were willing to switch to solar energy alternatives. It is a truism that photovoltaic solar home systems are highly priced. The unwillingness of relatively poor households to adopt solar home systems highlights the energy access gap that financial constraints engender. Our findings are similar to those of Billino (2009), Ugulu (2019) and Qu et al. (2019) who found that household income levels propel the willingness to adopt solar home systems (SHSs). This phenomenon calls for probes by all relevant stakeholders to consider ways through which SHSs can be made affordable irrespective of socio-economic status. This is expedient at a time when the inflow of technical and financial support from donor agencies have diminished over the years. The implications of this finding are that poorer households will remain stuck to environmentally unsustainable energy forms; thus, the emission of greenhouse gases will continue to rise, which will consequently drawback climate change mitigation objectives.

Over the years, Ghana's energy supply has not been able to meet the household demand, which has resulted in electricity supply limiting, a situation that has repercussions on productivity and quality of life. Asking how frequent respondents experienced power outages, we found that most of the respondents, constituting 39%, experienced power outage daily. For 318 respondents signifying 27%, they experienced power outages at four to six times weekly while 14% did two to three times and 20%, once weekly. This inconsistent supply of power according to the respondents has untold financial losses to their business and household expenditure as some registered that they had their electrical appliances being destroyed and foodstuffs kept in

refrigerators getting spoilt. Again, the use of electricity from the national grid, which most often is unreliable, has effects on home-based enterprises (HBE) which heavily rely on electricity for their daily business activities. The authors found that unit increase in power outage frequency increases the odds ratio of households adopting SHSs. This will only recede efforts to employ renewable energy access and constant power supply as pathways to poverty reduction and social mobility. This has an aggregate toll on economic development at both micro and macro levels. This finding solidly corroborates the stance of Gyamfi et al (2015) and Abokyi et al (2018) among others who have attested to the inconsistency of electricity supply in Ghana over the years. This finding again signals the need for the rearrangement of government policies and practice on the sources of electricity in Ghana. Evidently, the adverse impact of climate change where there have been shortfalls in rainfall will only see the diminishing ability of hydrogeneration plants to produce enough electricity for household and industrial consumption in Ghana. In addition, it is expedient that an electricity generation mix is adopted that accounts for the inability of conventional sources: hydro and thermal plants to provide constant electricity supply.

In addition, while further probing other factors that could influence the willingness to adopt solar energy by households, we found education to play a significant role. Respondents who had attained a form of formal education were more willing to adopt solar home systems relative to those who had not and again, the higher the level of education of respondent, the more willing they were to incorporate photovoltaic systems in their household source of electricity. This observation could perhaps be supported by the educational level of respondents where 12% had no formal education while the outstanding 88% had formal education to either primary, Junior Secondary School, Senior Secondary School or University levels. Again, we note from the regression analysis that a unit increase in education positively increases the odds of willingness to adopt SHSs but it is insignificant at all conventional levels. Overall, we found that most of the respondents who had received some level of education were willing to adopt solar home systems for their households. Recorded acceptance level was highest for people who had received education to the tertiary level with 31% of the sample size. Those without any level of formal education who were unwilling to adopt solar energy for their households represent 28% of respondents. Furthermore, more male-headed households were more receptive of adopting SHSs. This can be observed from the regression output, which indicates that for every unit increase in gender, that is, being male, the log of odds ratio indicates a

positive influence on willingness to adopt SHSs and is significant at the 10% level of significance.

Tenure arrangements were also influential in determining the willingness of households to SHSs. From the statistical analysis, property ownership exerts a negative influence and decreases the odds of households adopting SHSs, which is significant at both 5% and 1% significance levels. Tenants were mostly found to be unwilling to switch to solar home systems (SHSs) as they felt the houses did not belong to them and switching to solar energy at their own cost was off limit. This is because tenants consider themselves as lodgers who could be evicted at any time and that they stand the chance of losing the investment cost of installing and maintaining solar home systems (SHSs) in cases where property owners are not in favour of such systems and may refuse to refund such cost. This is implied from some of the respondents. A typical response is presented below:

> ***R34_TM:*** *I am only in Accra to work and as a public servant and may be transferred anytime my employers deem it fit. What happens if I am transferred just after contributing towards the installation of a solar system in this house? It means I will lose my money without enjoying it.*

In the case of compound houses with multiple households, adopting solar home systems was partially welcomed as a solution to contentions and challenges such as delays in terms of paying electricity bills where common meters were used. Regarding this challenge, which pertains to financial factors, a property owner respondent had this to say.

> ***R23_LM:*** *There are many tenants here who owe electricity bill for more than 3 months. If they are unwilling to pay, then how much more for solar panel systems in a house that does not belong to them.*
>
> ***R172_TF:*** *We do not intend to stay here for long to commit to such an investment. My husband and I are building and hope to move to our new house by the time our tenure here expires.*

Skepticism about the ability of solar home systems to support household electric appliances was a source of unwillingness to switch from the national grid. Across board, respondents who stuck to this position noted they were unsure how much of voltage can be produced to support home appliances like microwaves, washing, machines and kettles among others who are regarded to be high consuming appliances. The fear of these appliances bought at high prices being destroyed was a demotivation for the adoption of solar home systems. In the absence of these concerns, with a firm assurance that solar home systems can fully support household electrical consumptions, the prospects of its adoption, remain optimistic. This sends signals for

technological investments to equip solar photovoltaic energy systems to be commensurate with household energy consumption.

Recommendations and Conclusion

Electricity undeniably plays a crucial role in the everyday life of the household and the day-to-day running of micro and macro business. Unfortunately, however, the over-dependence on non-renewable energy sources coupled with the unpleasant kinetics of climate change has set back the supply of electricity in Ghana, which is heavily dependent hydroelectricity, and thermal plants, which use fossil fuel. With the importance placed on energy supply and economic development, as well as the ecological concerns about energy sources, it is necessary for the formulation and implementation of renewable energy options. The commitment to this agenda is evidenced in the policy documents of many international organizations and governments. For instance, the sustainable development goal (SDG) 15 of the United Nations seeks to achieve sustainable cities and communities and a proposed pathway is the adoption of renewable energy sources like solar panel systems.

Evidently, it is apt for households and other consumers of electricity in Ghana to embrace renewable energy sources for electricity, which SHSs comprise of. While this is so, many factors are likely to impede the willingness to adopt renewable energy sources and thus must be addressed to encourage solar energy adoption.

Disposable household income actuates the willingness of households to adopt SHSs. The consideration of many households is the financial cost associated with purchasing, installing, and managing solar home systems. As a panacea to this, relevant stakeholders including government, local assembly member, households and SHSs producers can liaise and design financially feasible plans for households who are willing to adopt SHSs. Other jurisdictions have introduced incentives and financial models that have increased solar panel system adoption by households. An instance is the enabling approach of the US government to encourage solar panel purchase agreements (SPPA). Financial options in this case can be based on piecemeal payment approaches as well as the provision of subsidies by governments, NGOs, and other relevant stakeholders. This will ease the outright financial burden that comes with the acquisition and installation process. In addition, in areas with no access to electricity, rather than incurring additional cost to add to the generation capacity of the national electricity grid, such funds can be channeled to the provision of solar home systems for households.

There is a need also to produce solar home systems that can harness enough solar energy to produce electricity that upholds the consumption rates of household appliances. Doing so gives the assurance of their ability of solar home systems to support everyday life. The prospects of evolving technology research will make this a possibility hence governments and relevant stakeholders may consider this option too.

Uptake of solar energy sources can further be encouraged through public education platforms by the Ghana Energy Commission. As shown from the data analysis that education positively influences the willingness to adopt solar systems, knowing and understanding the benefits that come with such systems will contributing to their adoption. In addition, the sidelining of solar photovoltaic energy systems as a reliable source of electricity and their ability to generate enough electricity indicates how unreliable they are regarded to be. While it is veritable that climatic uncertainties such as cloudy weathers and rainfalls may affect how much electricity can be generated, such downsides do not warrant the dismissal of photovoltaic energy systems. As a way forward, efforts should be made by the government, policymakers, and relevant stakeholders to see how these systems can be fused with traditional household electricity sources to balance consumption from both ends. This initiative will witness a fall in the financial commitment government and households are required to produce and access electricity, respectively.

In the wake of climate change impact minimizing campaigns, we urge the government to through policies and innovative means encourage the uptake of solar energy as economies are founded on effective economic activities and strategies. Efficient and constant power supply through solar energy opens the possibilities of businesses constantly engaged in activities that are heavily dependent on the power supply. Doing this has accompanying environmental and economic benefits. With the goal of reduced carbon emission in the wake of global warming and climate change concerns, the adoption of solar photovoltaic systems, which are environmentally friendly, will go a long way in helping achieve this.

For further research, it is recommended that studies should focus on how the country can increase its solar home systems production capacity and what incentive pathways could be explored to increase the uptake of solar home systems considering the many environmental and financial benefits they come with.

In conclusion, energy supply remains the crux of economic, social, and human development across the world. Expectedly, households and businesses have become heavily reliant of energy for their daily activities. The problem that besets this sector however is the overreliance on fossil fuel energy sources, which have been noted to be environmentally unsustainable due to

the greenhouse emissions, which manifest in global warming and other ecological upheavals. It is appropriate as a matter of urgency to promote the use of renewable energy sources for electrification. As promising as the benefits of this form of energy source is, its adoption is to a considerable extent influenced by social perceptions about renewable energy technologies, affordability; especially in the case of low-income households and the technical capacity of such technologies to support household electricity demand. We, therefore, recommend that relevant stakeholders such as government, solar home systems businesses, private sector entities and financial institutions should take pragmatic measures through policy formulation and implementation. This would make solar photovoltaic energy systems financially accessible and socially accepted by households.

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