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Financing electricity access in Africa: a choice experiment study of household investor preferences for renewable energy investments in Ghana.

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Financing Electricity Access in Africa: A Choice Experiment Study of Household Investor Preferences for Renewable Energy Investments in Ghana

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Abstract

Inadequate access to electricity is one of the pressing developmental challenges in Sub-Saharan Africa. Ensuring universal access by 2030 will require additional sources of finance as current investment volumes are inadequate. Increasingly, the integral role that household investors can play is being realised and understanding the preferences of such household investors is crucial to raising the necessary investments to bridge the gap. Using a discrete choice survey administered to Ghanaian household investors, this paper presents findings on household investor willingness to pay for the attributes associated with renewable energy (RE) investments and the effect of demographic variables on the likelihood of investing. The findings show that the track record of the developer is the most valued attribute associated with the highest marginal willingness to pay for RE projects. This was followed by the project viability attribute that represents the availability of support systems deemed necessary to enhance the viability of RE projects. Interestingly, the rate of return, although valued, was not the most important in the investment decision-making. Regarding demographics, young people (18-34 years) were found more likely than other counterparts to invest in renewable energy. Additionally, the findings establish the presence of heterogeneity between respondents for investment attributes. Finally, an investigation of the choice of technology showed that solar PV was the most preferred technology while wind energy is the least preferred. Overall, this paper highlights the importance of non-financial factors in the renewable energy investment decision making of household investors aside the rate of return.

Keywords: Households; choice experiment; willingness-to-pay; renewable energy; investments; energy access

Highlights

- A section of household investors have an interest in investing in RE.
- Highest WTP is associated with developer track record and project viability attributes.
- These two top attributes are proxies for risk investors attach to RE projects.
- Young people more likely than other counterparts to invest in RE projects.
- Solar PV is the most preferred RE technology and wind energy the least.
- Favourable policy and financial support needed to promote RE investments.

Word Count: 7373

1 Introduction

The electricity access challenge in Sub-Saharan Africa (SSA) is widely known. The World Energy Outlook report by the International Energy Agency (2018) estimates that about 600 million people lack access to electricity in SSA despite the massive untapped potential of renewable energy resources that could be exploited for an affordable and secure supply of energy (Barasa *et al.,* 2018). Inadequate investment or financing has been one of the major factors for the slow progress in achieving universal access with estimates around US$40 to US$55 billion a year (Briceño-Garmendia *et al.,*2008; Duarte *et al.,*2010; Eberhard *et al.,*2011; African Progress Panel, 2015; IRENA, 2015). Currently, there is overwhelming evidence that financing volumes are way below what is required suggesting that efforts need to be accelerated and innovative financing sources considered.

Increasingly, the role of citizens or household investors in financing renewable energy projects is being realised in many developed countries, for example, Germany, Denmark and Austria. However, citizens as financial actors in the electricity supply chain, particularly in power generation are less talked about in the low carbon transition discussion in Sub-Saharan Africa. One conjecture as to why citizens are given little prominence as financial participants may relate to poverty and saving rates across the sub-region relative to some places in the world. The different levels of electricity market reform across the region also hint at the difficulty in conceiving the possible roles of citizen investment in electricity provision.

Nonetheless, economic progress made in certain countries across the continent and the increasing realisation of developing ones local energy resources makes it timely to consider citizen investment. More so, many countries in SSA have expressed their commitment to exploit their renewable energy resources through their national energy plans with many setting targets to achieve the vision. For many countries, national energy plans tie into their nationally determined targets (NDCs) towards addressing climate change at the global level. According to IRENA (2015), 41 out of 54 countries had introduced renewable energy targets for at least one type of renewable energy with others taking a more sector-wide approach in the crafting of targets.For example, Ghana has a target of 10% renewable energy supply in the national energy mix by 2020 detailed in the strategic national energy plan(SNEP 2006-2020) (Energy Commission, 2006) which has now been extended to 2030 due to very minimal progress (0.3% renewable energy composition as at 2019)(Energy Commission, 2020).

Promoting citizen financial participation in the energy system in SSA has benefits outside financial gains. This includes stimulating the local economy due to local generation of income, contributing to a better understanding of climate and energy issues and creating niches that can be leveraged for future projects in other areas (Bergman and Eyre, 2011; Bolton and Foxon, 2015; Devine-Wright, 2014), promotion of behavioural changes in energy conservation (Hondo and Baba, 2004), directly reducing emissions and minimising the feeling of helplessness experienced by individuals or citizens (Heiskanen et al., 2010) and empowerment (Schreuer,2016; Lennon et al., 2019) as seen in the growing literature on energy democracy and justice. Curtin et al. (2017) also assert that this is a way to garner societal support for the energy transition. To leverage household investor financing for renewable energy power projects, understanding the preferences of such investors is essential – more so when many previous studies on investor preferences in the power sector have been highly skewed toward institutional investors like commercial trusts, hedge funds, pension funds among others.

This paper investigates the preferences of household investors for renewable energy investments using Ghana as a case study. Using data from a Choice Experiment (CE), the paper investigates the marginal willingness to pay for the different attributes, preference for technology and investigates preference heterogeneity by employing mixed logit and latent class modelling approaches. This paper contributes to bridging the gap in the literature regarding such preferences providing insights from an SSA developing country context. At the policy level, it provides information that may serve as a starting point for designing policies aimed at attracting citizen investment for renewable energy.

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature. This is followed by Section 3, which describes the applied experimental design, including methods, attributes and levels, and the design of the questionnaire. Section 4 describes the results of the survey and choice experiment, including respondents' investing style, choice of technology and willingness to pay. Section 5 summarises the paper by providing conclusions about the main research findings, implications for policymakers and further research.

2 Literature Review

Citizen investment borrows from the concept of "energy citizenship" which is a conscious effort of citizens to participate in all levels of engagement regarding ones' energy issues. Roberts et al. (2014) explain that this concept hinges on the idea that a wider consciousness among citizens can contribute towards the transition to a low carbon future. This consciousness encompasses citizen participation in the production and management of the energy they use sometimes termed "prosumer" or "community energy". This contribution is however steeped in a myriad of motivations well detailed in the literature to be the quest for economic gain or social reasons (Aitken, 2010; Walker and Devine-Wright, 2008; Walker et al., 2010; Yildiz, 2014; Bauwens, 2016). This informs the increasing realisation that if renewable energy projects are to compete favourably with traditional financial investments, they need to tick the profitability box in addition to their green credentials.

Financial theory literature has long established that sound investment decisions are influenced by the perceived risk and expected return. In other words, investors would typically require returns commensurate with the level of risk. Over the past decades, it has become increasingly evident that variables outside economics may drive individual investment decisions including in renewable energy. In fact, numerous studies in the field of behavioural economics and finance have done justice in establishing this link, that is, attitude and behaviour as predictors of financial decisions like investments (see Shiller, 1999; Barberis and Thaler, 2003; Campbell, 2006; Altman, 2012). Indeed, behavioural models like the Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB) have been applied in studying environmental preferences and behaviour in many settings (see Bang *et al.* (2000), Read *et al.* (2013), Stigka et al.,2014, Si et al., 2020). Studies have found that *a priori* beliefs, energy policy preferences, type of technology (technology risk attitude), investors experience, firm type, demographics all influence whether one invests in renewable energy (see Masini and Menichetti, 2012; Salm *et al.* 2016).

For better targeting of energy and environmental policies and products, the connection between renewable energy investment and investor demographics has been the subject of several studies. The literature details varying effects of demographic variables on investment attitude and behaviour with the emphasis often on gender, age, education and income. On gender, findings typically suggest that women are more likely to invest more in renewable energy. Aquilar and Cai (2010) find that females, on average, would invest about US$197.60 more than males in renewable energy. According to Nilsson (2008), women and better-educated investors were more likely to invest a greater proportion of their investment portfolio in SRI. Again, Hoque et al. (2010) find that the typical socially responsible investor is female, younger, wealthy and better educated. In terms of age, persons up to 35 years are considered more than likely than other counterparts to invest in RE or as age increases the likelihood of investing decreases (Aquilar and Cai, 2010; Gamel et *al.* 2016). On education, studies mostly establish that higher levels of education correlate with the willingness to pay for RE. These studies include Zarnikau (2003), Ek (2005), Sardinou and Genoudi (2013) and Tabi *et al.* (2014). On income, Zarnikou (2003) finds that as salary increases, willingness to pay a premium for renewable energy resources increases. Other studies, such as Mills and Schleich (2010) and Sardianou and Genoudi (2013) also find a positive correlation between income and the likelihood of investing in renewable energy technologies.

A review of the literature reveals a wide application of stated preference techniques (e.g. contingent valuation, choice experiments) to assess the willingness to pay for renewable energy products or renewable electricity. At the household level, the studies can be split between those who do so from "people as consumers" and from "people as investors in renewable energy" perspectives. The former often investigate what policies and programs citizens are most likely to accept, pay for or invest in, in line with government aim to increase the share of renewable energy (see Zarnikau, 2003; Bergmann et al., 2006; Borchers et al., 2007; Dimitropoulos and Kontoleon 2009; Zografakis et al., 2010; Oliver et al., 2011; Aravena et al., 2012; Arega and Tadesse, 2017; Graber et al., 2018).

Households or retail investors in the renewable energy investment space is a relatively nascent concept and as such the literature in the area is scanty and often contextualised from a European perspective - justifiably so because this phenomenon is a growing trend in the region. The few studies include Salm et al. (2016), Gamel et al. (2016), Curtin et al. (2019). Thus, there is a lack of empirical research focussed on household investor preferences in developing countries in Africa. However, the scale of the financing challenge for electricity access in SSA requires an all-hands-on-deck approach to financing making such research timely and useful for policy consideration around attracting citizen investment.

3 Materials and methods

3.1 Choice of methodological approach

Stated preference methods are employed to estimate economic values by asking individuals survey questions to elicit their preferences (Johnston et al., 2017; Hanley and Czajkowski, 2019). They are valuable in circumstances where information cannot be gathered by observing behaviour in actual markets or where historical data is absent (Curtin et al., 2019). In this paper, the preferences of household investors for renewable energy investment is analysed using a choice experiment (CE) which is a well-known stated preference method. In a choice experiment, respondents are presented with hypothetical but realistic choice situations to determine their utility. CEs are based on random utility theory (RUT) (McFadden, 1974) and Lancaster's characteristics theory of value (Lancaster, 1966). Lancaster's theory states that consumers do not derive satisfaction (utility) from the good itself but the characteristics of the good - that is, the value of a good is the sum total of its individual characteristics. RUT, which is the theoretical foundation, allows for the indirect estimation of an individual's preferences from two components: an explainable component and random component, as shown below:

$$U_{iq} = X_{iq} + \varepsilon_{iq} \qquad \textbf{3.1}$$

where U_{iq} is the latent unobservable indirect utility of consumer *q* for choice alternative *i*, X_{iq} is the observable or deterministic component for consumer *q* for choice alternative *i*, ε_{iq} is the random or unexplainable component of the utility that consumer *q* has for choice alternative *i*.

Multinomial (MNL) models present a simple model for assessing preferences; however, the assumptions of the Independence of Irrelevant Alternatives (IIA) and uncorrelated unobserved error over time assumptions (Yoo and Ready, 2014) make it unable to account for preference heterogeneity as preferences are considered fixed for all respondents. Model alternatives that allow for preference heterogeneity and relax the IIA are the mixed logit model and latent class models (Train, 1998, Greene and Hensher, 2003), both of which are applied in this paper.

The mixed logit model overcomes the restrictions imposed by the MNL model and allows heterogeneity in taste by assuming that parameter coefficients (β) for the attributes vary over across respondents which leads to the utility specification:

$$U_{iq}=\beta_q' X_{iq} + \varepsilon_{iq} \qquad \textbf{3.2}$$

For each respondent, the utility function has random taste parameters β_q' which are based on the values of the parameter θ of the underlying distribution f (β|θ). Its name the mixed logit is derived from the fact that it is a mixture of logits with mixing distribution *f*. Like the MNL model, however, it is the estimation involves maximising the likelihood function. The outputs results from mixed logit models identify the degree of heterogeneity in taste and preferences captured in the standard deviation associated with each attribute coefficient. Often, alternative specific constants (ASCs) which are modelling constants can be included to capture the respondent's inherent preference for that alternative irrespective of other covariates in the model (Scarpa et al., 2005; Bergmann et al., 2006). Compared to the MNL, it is more considered more practical and realistic.

In discrete choice experiments, marginal willingness to pay/implicit price measures are often the goal as they are essential for many reasons such as informing policy through the pricing of goods and services (Hanley *et al.,* 2003), as crucial inputs in economic valuations like cost-benefit analyses (Logar *et al.,* 2019) and assessing the desirability of goods and services through relative comparisons and ranking (Hole and Kolstad, 2012). The marginal willingness to pay (WTP) measures the relative importance of a unit change in an attribute in monetary terms. In other words, it represents a 1% or 1 unit increases in the quantity of the attribute being measured. If the attribute is qualitative, this represents a discrete change. Hence, the WTP can be used to indicate the extent to which household investors would be willing to pay for a range of renewable energy investment attributes.

The standard approach to calculate willingness to pay for a marginal change in the level of provision of an attribute by dividing the coefficient of the attribute by the coefficient of the price or cost attribute (sometimes referred to as implicit price).[1] Hence, the implicit price for an attribute *k* is given as

$$Implicit\ price\ for\ attribute\ k\ =\ -(\frac{\beta_k}{\beta_m}) \qquad \textbf{3.3}$$

where β_k and β_m is the estimated coefficient for the *kth* attribute and monetary (price) attribute, respectively. In this paper, the marginal willingness to pay measures for the different renewable energy investment attributes provides information about what investment attributes investors value the most and how much they are willing to pay.

To complement the mixed logit model in the assessment of preference heterogeneity, a latent class model is also employed. The latent class model is a semi-parametric model (Greene and Hensher, 2003) which is increasingly growing in its use to study preference heterogeneity among discrete choice researchers. The LC model assumes that individuals base their decision making on a set of observable attributes and a set of latent factors invisible to the analyst (Greene, 2001). Based on the assumption that attributes of the alternatives can be heterogeneous across groups and homogenous within groups, it allows for categorisation of the sampled population in segments that will enable useful deductions about the study population.

3.2 Experimental design

3.2.1 Selection of attributes and attribute levels

The process of designing the discrete choice experiment was composed of two key stages. The first step considered truly critical is the identification of attributes and the assignment of levels (Hensher *et al.* 2005, Coast *et al.* 2012). A combination of qualitative methods based on interviews, groups discussions, expert opinions or a literature review can be employed. For this study, the relevant attributes and levels were determined using a literature review and three focus group interviews. The focus groups were conducted in January 2017 in the capital city of Ghana, Accra with household investors. Participants had to be gainfully employed and make at least $10 a day a starting point for the global middle class.[2] After this qualitative study, six attributes for renewable energy investments

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[1] It is important to mention that measures such as implicit price or WTP are not affected by scale parameters because they cancel out.

[2] The income screening measure was used to ensure that participants typically had savings for investment to enhance the validity of responses. Excluding those below the poverty line, the middle class is considered a strong starting point as this group has consumption outside physiological needs such as food, water and shelter.

were selected for the discrete choice experiment. They were: (1) Rate of return on investment; (2) Track record of the project developer; (3) Project viability; (4) Price of investment; (5) Hold time/holding period; and (6) Origin of project developer (See Table 1).

Attributes	*Description*	*Levels*
Rate of Return	This is a measure of how profitable the investment is. A high return denotes high reward and vice versa for a low return.	5%, 8%, 11%, 14% and 17% per annum
Track Record of the Project Developer	This captures the experience or achievements of the developer in delivering similar projects in the past. This is a subset of the overall reputation of the developer.	**None** (This will be the first project being undertaken) **Some (**Executed five similar projects in the past) **Lots (**Executed more than five similar projects in the past)
Project Viability	This is a measure of how a project will survive, remain profitable and grow. For power projects, certain rights and guarantees enhance the viability of a project, and the more of these guarantees exist for a project, the greater the likelihood of it surviving and remaining profitable. These include the right to grid access, a guaranteed feed-in-tariff (FiT), investment subsidies and a long-term contract (LTC).	**Low** (Right to grid access) **Moderate** (Grid access + FiT) **High** (Grid access+ FiT +Investment subsidies) **Very high** (Grid access + FiT + Investment subsidies + long term contract)
Price of Investment	This is the minimum amount required to partake or own a share in the investment.	GHS350, GHS500, GHS 650
Hold Time	This is the time between purchasing the investment and when it can be sold.	9, 18, 27, 36 months
Origin of project developer	This refers to where the firm developing the power plant originates. In this study, the options under consideration are domestic (local) or foreign (international). This is also a subset of the developer reputation characteristic.	Domestic (Ghanaian) International (Foreign)

Table 1 - Selected attributes and associated levels

For all attributes, a total of 21 levels were obtained. Determination of levels was done through a thorough literature review and expert opinion regarding what pertains in the industry. For the return on investment attribute, country research on treasury bills (the status quo investment alternative) and renewable energy investment return rates were considered. At the time of designing the survey in July 2017, Treasury bill rates were approximately 12 % per annum for 91-day Treasury bills (Data Bank Research, 2017).[3] Investment news on renewable energy project yields from funds often report at least a 5% interest per annum in the UK and the US (Financial Times, 2018). For example, the UK crowdfunding platform Abundance in 2016 gave investors about 6% annual return for direct investment in renewable energy projects through bonds. It is well known that the average returns on projects in emerging economies can be double that of developing countries – perhaps reflecting the higher risk in these regions. Hence, a lower limit of 5% with 3% increments to reflect old and prevailing country investment alternatives were used.

The developer track record was measured by the number of similar projects executed as discussed in focus groups. As Shefrin (2001) would argue, investors see companies with a high reputational rating as excellent investment opportunities, and for a project developer, execution of projects to expectation is a key consideration – a good signal of competence and trustworthiness. A lower limit of "no track record" and higher limit of having completed more than five similar projects in the past was used. The level associated with "origin of developer" attribute was clear cut in focus group discussions where respondents distinguished between local and foreign (international companies). The price for investment was obtained by considering the minimum requirements for investing in well – known options like treasury bills. Research from financial institution showed a minimum of GHS500 (~ USD 110) for treasury bills. Mutual funds have lower minimums starting at around GHS50 (USD 12) depending on the institution. The minimum for treasury bills was used as a midpoint minimum, and GHS350 and GHS650 used as lower and upper limits respectively for the minimum price.

In choosing the levels for "project viability" attribute, it was observed throughout the literature that the viability of most energy projects, including renewable projects, is affected by the presence or lack of support systems and policies. Issues such as regulatory uncertainty, demand uncertainty and permitting process uncertainty have been identified as problems that undermine the development and viability of projects (Lee and Zhong, 2015). The reduction of these risks often helps to boost investor interest (Dinica, 2008; Gatzert and Vogl, 2016). In the renewable energy space, access to the grid, guaranteed feed-in -tariffs, investment subsidies and long-term contracts have been employed to deploy renewable energy projects to varying degrees of success around the globe and especially in countries in Europe. These support schemes were combined to give levels low, moderate, high and very high.

The hold time/ holding period denotes the minimum time after the investor can withdraw the initial investment. Included were four levels starting at nine months to 36 months (3 years). This was to assess the preferred time horizons for renewable energy investment.

3.3 Design and structure of the choice questionnaire

Because a fully orthogonal design would have yielded 1,440 combinations of alternatives from the six attributes with 21 levels which can be impractical in many cases, a fractional factorial was generated using SPSS version 22 to reduce alternatives to 29 alternatives. Each choice set contained two of the generated alternatives, a status quo and opt-out alternative. The status quo alternative was to allow respondents the option to invest in the existing financial investment of government treasury bills while the opt-out alternative was present for those that were not interested. This was to ensure that the survey was realistic and practical as an investment opportunity in the real world. Before the choice survey was administered, participants were presented with the scenario on which to base their investment choices. This was as follows:

"Please imagine you have GH¢1000 to invest in a grid connected solar photovoltaic power project or use to buy 91-day treasury bills. The GH¢1000 is money you have saved from your salary with an intention to invest it. You are required to indicate how you would invest this money from the selection of investment options provided with the assumption that you can make at least one

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[3] Data Bank is an investment bank in Ghana offering a range of investment products and research to organisations. It reported interest rates for treasury bills remained above 20% during the first three quarters of 2016. This was attributed to issues of inflation uncertainty, tight GHS liquidity, banks' reduced desire for credit expansion and high refinancing risk faced by the government.

potential investment. Later on in this survey, you will come across several different choice cards and be asked how you choose to invest this money. On each choice card you have the option to invest in the solar PV power project (option A or B) or in a 91-day government treasury bill or None."

Each respondent was then provided with eight choice cards and asked to state their preferred option. A sample choice card is given in Table 2. Options A and B are associated with the change being measured (that is, investing in renewable energy projects); C is the status quo option while D is the opt-out option.

CHOICE CARD BROWN

Characteristics	**Option A**	**Option B**	**Option C**	**Option D**
Track record of developer	Some	None	Invest in Treasury bills at 12% for 91 days	None
Origin of developer	International	Domestic		
Cost of Investment	500GH¢	350GH¢		
Return on Investment	5%	8%		
Viability	Very High	Low		
Hold Time	36 months	36 months		

In which option would you **most likely** invest?

- ☐ A
- ☐ B
- ☐ C
- ☐ None
- ☐ Decline to Answer

Table 2 - Example of a choice set

The overall questionnaire consisted of three parts: In the first part, respondents were asked to provide information about their investing style with options to depict experience with investing, risk tolerance and motive for investing. The second part was the main choice experiment whilst the third and final section collected personal information regarding gender, age, occupation, education and income. The complete questionnaire survey was pretested in August 2017 with a small sample (20 respondents) to measure clarity and cognitive burden. This led to some revisions before final survey administration in October 2017.

3.4 Sample and data collection

Considering that national populations have persons belonging to different income groups, including those below the poverty line, targeting household investors required an approach that screened for income. The middle class is considered a strong starting point as this group has consumption outside physiological needs such as food, water and shelter. More importantly, this class is likely to have more disposable income or more substantial savings than the poor (Chun *et al.,* 2017) enabling them to save and invest hence a more likely target group for investing.

The absolute approach definition for global members of the middle class is people who earn between US$10 and US$100 per day per capita in purchasing power parity terms (Kharas, 2010 and Kharas and Gertz, 2010). The minimum threshold of US$10 was used as a minimum for inclusion. Hence the lower band for inclusion in the choice questionnaire was GHS15,001-GHS25,000 (USD3,489-USD5,814) per annum. No upper limit was set for inclusion in the survey. By screening for income, other qualitative measures associated with the class like 1. having higher levels of tertiary education 2. living in urban centres in bigger dwellings with modern equipment as well as harnessing technology 3. young and in the acquisitive phase of life 4. holding salaried jobs or are small business owners (Leke *et al.* 2010) and Deloitte, 2012) were satisfied.

A paper-based questionnaire was administered face to face in Accra, the capital city as it has the highest percentage of households in the fourth- and fifth-income quintile who are most likely to meet the income requirement. A combination of recruitment methods was used including visiting business and educational institutions and setting up in key professional event centres like the Accra International Conference Centre (AICC) that hosts many conferences from different industry groups annually. Potential survey participants were screened for income, and if they did not meet criteria, the questionnaire was not administered. Using this approach, only about 10% of persons approached failed the income screening. Altogether about 250 paper-based questionnaires were administered. Two hundred and one questionnaires were obtained in all corresponding to an 80% response rate. No incentives were utilised for the survey. For many respondents, a description of the study and its aims were enough for subscription.

3.4.1 Respondent demographics (descriptive statistics).

Out of the 201 participants surveyed, 129 identified as male while 72 were females representing 64.2% and 35.8% respectively. Survey respondents were aged between 18 to 65 years, as seen in Figure 1– a range exemplifying an active work population. The least represented are individuals older than 64, who represented 2% of total respondents. It may be noteworthy to add that many African countries have a young demographic population (UNECA, 2016). More than 90% of respondents had at least a University degree or Diploma. Those with University education only represented 49% while those with a master's degree represented about 46% (as seen in Figure 2).

Least represented are those without a degree and those with more than a master's degree. The occupational classification used in this study was adopted from the Ghana Living Standard Survey (GLSS) classification and is consistent with the International Standard Classification of Occupation (ISCO-08) index. Majority of survey respondents from Figure 3 identified as professionals/managers/legislators. According to the GLSS survey, professionals and managers/legislators receive the highest average monthly earnings, while the lowest-earning were among skilled agricultural/fishery worker. This explains the dominance of professionals and managers in the survey and the underrepresentation of the skilled agriculture class. Lastly, Table 3 provides a breakdown of the annual household income for respondents, income category per day (2017 PPP) and how this compares with the AfDB and global middle-class income benchmarks.

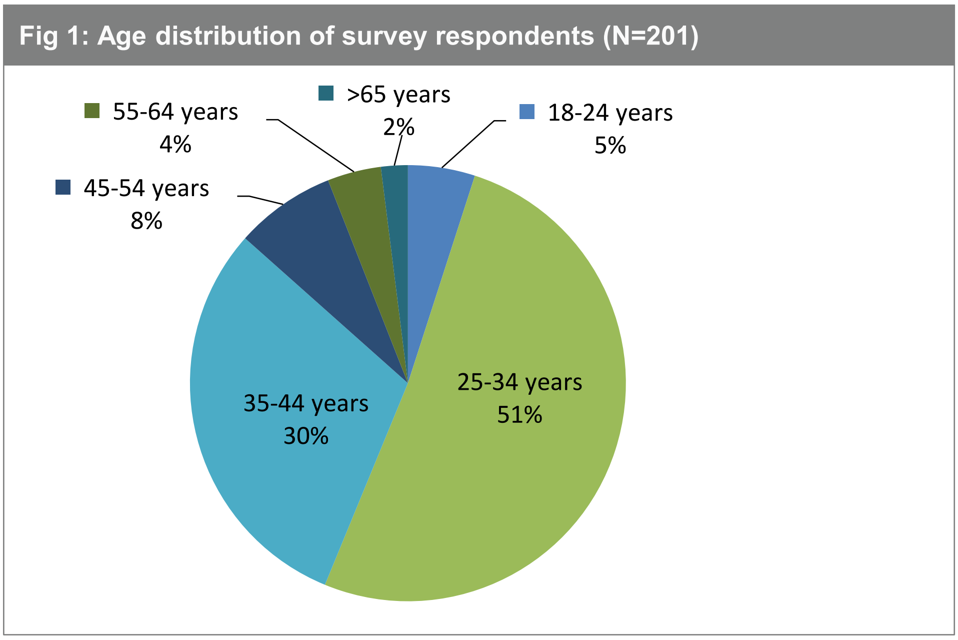

Figure 1 - Age distribution of survey respondents

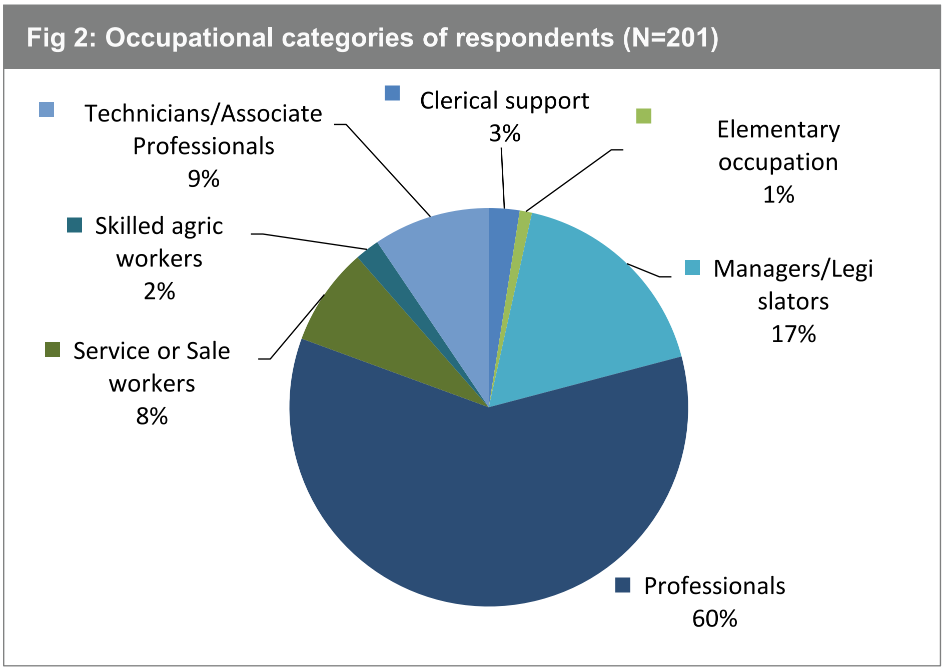

Figure 2 - Occupational categories of respondents

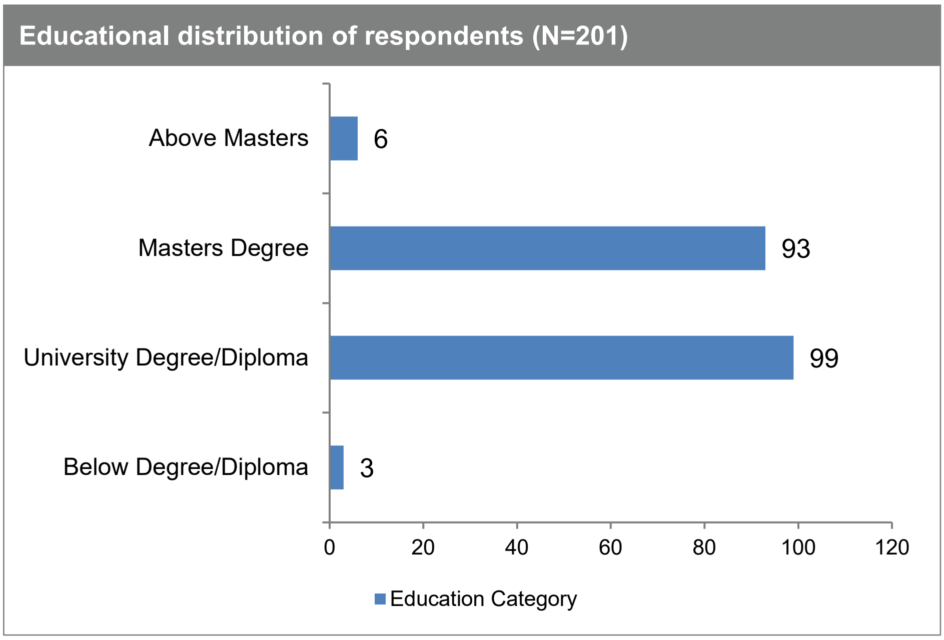

Figure 3 Educational distribution of respondents

Income Category (GHS)	Income Category (USD, 2017 Exchange Rate)	Income Category Per Day (USD, 2017 Exchange Rate)	Income Category (USD, 2017 PPP)	Global Middle Class Benchmark (USD per day PPP)	AfDB Upper Middle-Class Benchmark (USD per Day PPP)	No. of respondents	% of Respondents
15,001-25,000	3,489-5,814	10-16	21-35	10	10-20	56	27.90%
25,001-35,000	5,814-8,140	16-22	35-49	10	10-20	25	12.40%
35,001-45,000	8,140-10,465	22-29	49-62	10	10-20	29	14.40%
45,001-55,000	10,465-12,791	29-35	62-76	10	10-20	20	10.00%
55,001-65,000	12,791-15,116	35-41	76-90	10	10-20	14	7.00%
65,001-70,000	15,117-17,742	41-48	90-104	10	10-20	14	7.00%
75,001-85,000	17,742-19,767	48-54	104-118	10	10-20	12	6.00%
>85,001	19,768	>54	118	10	10-20	31	15.40%
Total						**201**	**100**

Table 3 - Annual household income distribution of respondents

4 Results and discussion

Here, the results of the discrete choice experiment are presented. The discrete choice study aimed to investigate the preferences of household or retail investors for renewable energy investments. Specifically, it sought to address the following key objectives: (1) to determine the marginal willingness to pay for renewable energy investment attributes; (2) to determine where heterogeneity exists, if any, in preferences for attributes; and (3) to investigate the effect of demographic variables like age, education and income on the likelihood of investing.

4.1 Preliminary survey questions results

First, respondents were asked about their investing style and asked to tick all that apply. Figure 4 shows that while 13.43% considered themselves “experienced”, 8% described themselves as “Novice”. On the frequency of investment, almost 20% described themselves as occasional investors with less than 10% for both “often” and “rare” categories. Respondents’ description of their risk appetite was the most answered investment style category. About 35% of respondents described themselves as “balanced risk”, 10% for low risk with only 9% opting for “high risk”. Lastly, on the motive for investing, only one person (0.50%) considered himself a recreational investor. The motive for investment was split between people who consider themselves purely profit-seeking and socially responsible investors, that is, 11.44% and 14.92% respectively. This shows that household investors are not a homogenous group and differing motives and risks appetites hint at their heterogeneity.

Secondly, survey respondents were asked about their most preferred choice of renewable energy technology amongst four renewable energy technologies (solar PV, wind, hydro and biomass) in a ranking exercise. Results shown in Figure 5 show that solar photovoltaics was the most preferred technology type endorsed by more than 60% of respondents. This is followed by small hydro endorsed by 20% as their first technology of choice. In the third and fourth positions are biomass and wind energy respectively. These results are similar to the findings of studies like Borchers *et al.* (2007), Aguilar and Cai (2010), Yoo and Ready, 2014; Salm *et al.* (2016) who report a greater preference/highest WTP for solar photovoltaics or power. This finding is no surprise as solar and wind dominate renewable energy investments globally (BNEF, 2018) showing the confidence investors associate with these technologies. At the country level, focus group respondents in this study expressed confidence in solar technology as many had positive experiences with its use from gadgets such as solar torches and lamps.

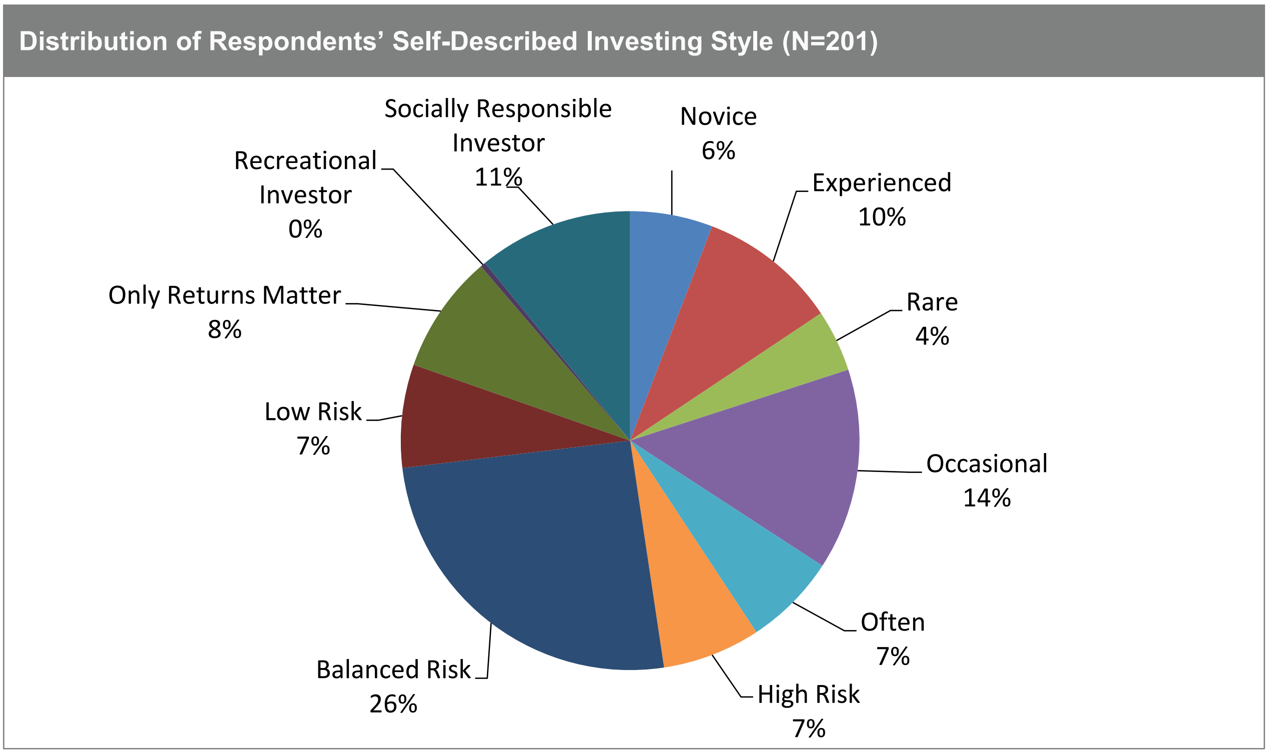

Figure 4 - Distribution of respondents' self-described investing style (N=201)

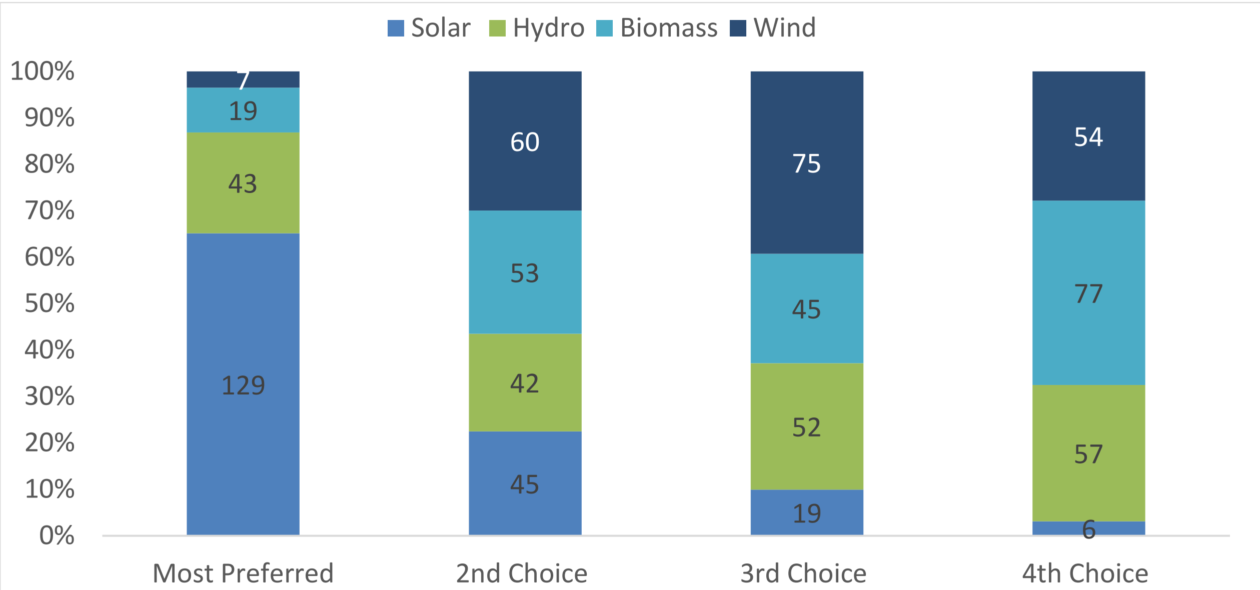

Figure 5 - Respondent's ranking of renewable energy technologies (N=199)

4.2 Mixed logit model

To calculate the willingness to pay, two mixed logit models were estimated - one with the price fixed and the other with the price randomised. The fixed price model (Model I) is found to the left and the random price model (Model II) to the right. From Table 4, Models II, where the price coefficient was randomised has a very slight improvement in the goodness of fit than Model I where the price coefficient was fixed. This approach was taken because, in many cases, price is fixed for WTP measures for convenience however in this study it was considered unrealistic to assume that all respondents had the same sensitivity to the price of the investment. The standard deviation for random parameters for price, hold time, track record, origin of developer and ASC_C (status quo) are significant, providing evidence of the unobserved heterogeneity of preferences among respondents.

Model I (Price Fixed)			Model II (Price Random)		
Choice	**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**
Fixed Variables	**Mean**		**Fixed Variables**	**Mean**	
Price	-0.004**	0.001	Price	-0.004**	0.001
ASC_A*Female	-0.612	0.504	ASC_A*Female	-0.565	0.534
ASC_B*Female	-0.414	0.513	ASC_B*Female	-0.344	0.526
ASC_C*Female	0.688	0.842	ASC_C*Female	0.676	0.858
ASC_A*Young	1.774*	0.718	ASC_A*Young	1.835*	0.771
ASC_B*Young	1.720*	0.732	ASC_B*Young	1.780*	0.76
ASC_C*Young	1.226	1.407	ASC_C*Young	1.107	1.198
ASC_A*MiddleAge	-0.027	0.639	ASC_A*MiddleAge	0.113	0.738
ASC_B*MiddleAge	-0.416	0.653	ASC_B*MiddleAge	-0.257	0.729
ASC_C*MiddleAge	-0.902	1.427	ASC_C*MiddleAge	-0.694	1.285
ASC_A*BaseInc	-2.048*	0.985	ASC_A*BaseInc	-2.035*	1.025
ASC_B*BaseInc	-2.418*	1.001	ASC_B*BaseInc	-2.392*	1.022
ASC_C*BaseInc	-2.472	1.424	ASC_C*BaseInc	-3.037*	1.506
ASC_A*MidInc	-2.028*	0.917	ASC_A*MidInc	-2.019*	0.952
ASC_B*MidInc	-2.043*	0.929	ASC_B*MidInc	-2.033*	0.945
ASC_C*MidInc	-3.437*	1.398	ASC_C*MidInc	-4.016**	1.393
ASC_A*UpperInc	-1.494	0.935	ASC_A*UpperInc	-1.25	0.966
ASC_B*UpperInc	-1.649	0.949	ASC_B*UpperInc	-1.448	0.96
ASC_C*UpperInc	-3.292*	1.438	ASC_C*UpperInc	-3.531**	1.358
ASC_A*HiEduc	1.069*	0.483	ASC_A*HiEduc	0.945	0.514
ASC_B*HiEduc	1.133*	0.493	ASC_B*HiEduc	0.996*	0.508
ASC_C*HiEduc	1.281	0.94	ASC_C*HiEduc	1.248	0.862
Rate of Return	0.081**	0.023	Rate of Return	0.082**	0.024
Origin_Domestic	0.624**	0.155	Origin_Domestic	0.651**	0.161
HoldTime	-0.028**	0.008	HoldTime	-0.030**	0.008
TrackRecord_Some	1.859**	0.201	TrackRecord_Some	1.879**	0.206
TrackRecord _Lots	1.773**	0.211	TrackRecord _Lots	1.802**	0.217
Viability_Moderate	0.545**	0.176	Viability_Moderate	0.535**	0.178
Viability_High	1.199**	0.205	Viability_High	1.222**	0.21
Viability_Very high	0.938**	0.174	Viability_Very high	0.969**	0.177
ASC_A	2.957**	0.982	ASC_A	2.992**	1.007
ASC_B	2.989**	0.995	ASC_B	3.063**	1
ASC_C	3.056*	1.599	ASC_C	3.434*	1.345

Randomised Variables	Standard Dev.	Std. Err.		Standard Dev.	Std. Err.
			Price	0.002**	0.001
Rate of Return	0.099**	0.024	Rate of Return	0.104**	0.021
Origin_Dom	-0.880**	0.178	Origin_Dom	0.967**	0.169
HoldTime	-0.031*	0.012	HoldTime	0.021	0.021
TrackRecord_Some	0.537*	0.225	TrackRecord_Some	0.527*	0.223
TrackRecord_Lots	0.628*	0.304	TrackRecord_Lots	-0.704**	0.269
Viability_Moderate	0.023	0.382	Viability_Moderate	-0.191	0.34
Viability_High	-0.356	0.581	Viability_High	0.514	0.42
Viability_Very high	0.347	0.414	Viability_Very high	0.382	0.338
ASC_A	-0.037	0.396	ASC_A	0.029	0.287
ASC_B	0.249	0.224	ASC_B	-0.145	0.328
ASC_C	4.520**	0.517	ASC_C	4.518**	0.516
Observations	**1599**			**1599**	
Log-Likelihood	**-1343.615**			**-1340.007**	
AIC	**2775.23**			**2770.014**	
BIC	**3072.787**			**3074.333**	

*Note: **, * = Significance at 1% and 5% level*

Table 4 - Estimation results for mixed logit models

The estimated parameters(means) are significant for all attributes and have the expected sign. As expected, the coefficient for minimum "Price" for investment is negative and highly statistically significant. This shows that on average, respondents shy away from investments that require a higher minimum price for the investment. Similarly, the negative coefficient associated with "Hold Time" suggests that respondents on average dislike investments with longer holding times. In terms of developer track record, the positive coefficient for levels "some" and " lots" show that respondents favour investments whose developers have "some" and "lots" of track record which translate into a developer having completed five or more similar projects in the past. Also, respondents prefer project developers of domestic origin to foreign counterparts as can be seen from the positive coefficient. On the project viability attribute, respondents prefer investments with increasing renewable energy support systems as shown with the positive coefficients associated with "moderate", "high" and "very high" project viability attribute levels compared to a renewable energy project with only guaranteed grid access. The significant positive sign of the alternative specific constants (ASCs) for renewable energy options (A and B) and status quo option, that is, government treasury bills (option C) suggests a positive preference for both types of investment. In implied ranking, however, the status quo alternative is relatively more valued with (β=3.43) compared to that of option A and B which are (β=2.99) and (β=3.06) respectively.

On the effect of socioeconomic variables on investment choice, gender was not found as a statistically significant determinant of preferences however being young(18 to 34) was associated with a significant positive coefficient for renewable energy options A and B. For income, respondents belonging to the lowest income category showed the most negative preference for investing across all alternatives. Also, ASCs show a strong positive preference for investing in renewable energy projects as well as the status quo, which is government treasury bills. What this means is that the sample has respondents who inherently prefer investing in government treasury bills as well as in renewable energy.

4.3 Marginal willingness to pay estimates for the mixed logit model

Table 5 reports the marginal willingness to pay or implicit prices of the attributes used in the choice experiment calculated using the mixed logit model with randomised price coefficient (Model II). All estimated variables are statistically significant at the 1% level and associated with a positive willingness to pay except the hold time variable. The highest willingness to pay (GHS 476) is associated with the track record attribute, precisely a developer with "some track record" interpreted as a project developer who has completed five similar projects in the past. Conversely, the lowest willingness to pay is associated with the hold time attribute implying that respondents are willing to pay less (GHS -7.85) for increases in investment hold time. From the results, all other attributes/variables being equal, respondents are willing to pay GHS19.47 more for every 1% increase in the investment rate of return. With regards to the track record of the project developer, on average, respondents are willing to pay more for an investment whose developer has "some" and "lots" of track record (GHS476 and GHS422 respectively) compared to a developer with no track record.

Attributes	**Estimates in GHS**	**[95% Conf. Interval]**	**Standard error**
Rate of Return (%)	**19.47****	9.39 - 29.53	5.14
Track record (some) (as compared to a developer with no track record)	**476.16****	334.14 - 618.18	72.46
Track record (lots) (as compared to a developer with no track record)	**442.53****	287.05 - 598.01	79.33
Developer origin (domestic) (as compared to a developer of international origin)	**147.92****	52.87 - 242.97	48.50
Viability (moderate) (as compared to a project with low project viability)	**154.34****	50.27- 258.41	53.10
Viability (high) (as compared to a project with low project viability)	**315.18****	164.21 - 466.16	77.03
Viability (very high) (as compared to a project with low project viability)	**252.56****	143.98 - 361.13	55.40
Hold Time	**-7.85****	-12.05 - 3.64	2.14

*Note: **= Significance at the 1% level. Values in GHS (GHS 1 approx. US$0.2)*

Table 5 - Marginal WTP estimates with mixed logit model in WTP space

Similarly, on average, respondents are willing to pay more for an investment with a moderate, high and very-high project viability metric compared to a project with low viability (that is, a power project with only guaranteed grid access). The highest willingness to pay among the level of project viability is “project viability (level high)” denoting a project with grid access, guaranteed feed-in-tariff and investment subsidies. Within this attribute, the lowest WTP is associated with the level “moderate” which is a project with grid-access and a feed-in-tariff. Presently, this is the support system available for many renewable energy projects in Ghana, and this has proven insufficient in driving the necessary investment in the sector. Lastly, respondents show a preference for a project developer of domestic origin compared to a developer of international origin. On average, all other variables being equal, respondents are willing to pay GHS147 more for an investment with a domestic project developer.

4.4 Latent class model

To further explore preferences within the sample, a latent class model is estimated. Estimating a latent class model requires the prior identification of the optimal number of classes based on a statistical fit assessment (Louviere *et al.,* 2000; Green and Hensher, 2003). This entails comparing the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), consistent AIC (CAIC) for a number of classes. The best class is deemed the one with the lowest values for information criterion. As shown in Table 6, a three-class model was more appropriate for the data as evident from both the AIC and BIC measures. The latent class model presented below is considered the best addition to the mixed logit model reported earlier in identifying unobserved preference heterogeneity among respondents. The latent class choice model was estimated using Stata Lclogit model, which utilises an expectation-maximization (EM) algorithm for parameter estimation (see Pacifico and Yoo, 2012).

In the LC model (Table 6), the variables “Track record (some)”, “Track record (lots)”, “Project Viability (high)”, “Hold Time” and “Status Quo” are significant across all classes. Of notable importance is the preference for the status quo across classes. Members of class 3, 45.5% of the sample population are likely candidates for considering alternative investments like renewable energy investments due to their negative preference for the status quo. Members of this class show slightly less preference for chasing rate of return as well as less sensitive to the minimum price for investment though not statistically significant. Their preference for accommodating higher holding times and a local developer adds credence to why this group are likely candidates for attracting such investment. Overall, this investor group can be regarded as less risk-averse.

Conversely, members of Class 2 may be regarded as “return chasers” and have the largest positive preference for the status quo investment as well as the rate of return. They also have a negative preference for a developer of domestic origin though this is not statistically significant- thus members of this class are indifferent to whether the developer is local or foreign. This class is also the most sensitive to investment hold time and increases in the price of investment though the latter is not significant. Members of this class also have a strong statistical preference for a developer with a lot of track record. This group (27% of the sample) can be regarded as the most risk-averse and less likely to invest in renewable energy projects all things being equal.

Table 6 - Parameter estimates for the Three Class Latent Class Model

Variable	Class 1	Class 2	Class 3
Status Quo (ASC_C)	1.060** (0.208)	6.072**(1.285)	-1.374**(0.539)
Track record_some	1.658 **(0.287)	1.036*(0.481)	1.881**(0.253)
Track record _lots	1.362**(0.308)	2.567*(1.190)	1.755**(0.326)
Origin of developer_domestic	0.978**(0.228)	-0.311(0.568)	0.872**(0.209)
Rate of Return	0.013(0.026)	0.548**(0.146)	-0.015(0.038)
Viability_moderate	0.347(0.299)	2.22 ** (0.658)	0.639*(0.273)
Viability_high	1.641**(0.307)	1.721**(0.548)	1.190**(0.352)
Viability_very high	0.652**(0.239)	0.016(1.143)	0.509*(0.214)
Hold Time	-0.024**(0.010)	-0.137**(0.045)	0.052**(0.017)
Price	-0.002*(0.001)	-0.006(0.003)	.000(0.001)
Class Share	**0.271**	**0.274**	**0.455**
No of Observations	1599		
Log-Likelihood	-1387.84		
AIC	2839.68		
BIC	2945.38		

*Note: **, * = Significance at 1% and 5% level. Omitted levels are "No track record", "International developer(origin)" and "Low project viability".*

Table 6 - Parameter estimates for the Three Class Latent Class Model

Members of Class 1 also prefer the status quo investment alternative, are sensitive to the increases in the minimum price of the investment as well as investment hold time. They also prefer a developer of domestic origin and well as a developer with some and lots of track record. They have a positive preference for increasing rate of return though this is not significant. This group, although have a positive preference for the status quo, demonstrate a relatively smaller preference compared to members in Class 2. Members in this class can be likely investors of renewable energy projects if the investment profile fits their needs.

4.5 Discussion

From the results, it is evident that to attract household investment into renewable energy, the perceived risks investors attach to such investments must be addressed. The highest willingness to pay associated with the track record of the developer attribute can be described as a "proxy" for the riskiness of the investment. Specifically, respondents were willing to pay the highest for a developer who had completed five similar projects in the past. This is not surprising as such projects or initiatives are relatively new and carry a significant risk of failure over the lifecycle of the project (Noothout et al., 2016). The literature on RE project risks cites resource quality, availability and cost risks, technology risks, construction risks, planning and approval risks, environmental risks, interest rate risks, currency exchange risks, institutional and regulatory risks that project developers must scrutinize for (see Dinica, 2006; Bhattacharya & Kojima, 2012; Arnold & Yildiz, 2015; Shimba & Ebrahimi, 2020). The ability of the developer to complete similar projects in the past thus hints at their effectiveness in managing all the risks to secure investor funds.

Similarly, respondents were willing to pay the highest for a project with adequate renewable energy policy and financial support systems, that is, guaranteed grid access, feed-in-tariff and investment subsidies. A plethora of studies including Wustenhagen and Menichetti(2012), Masini and Menichetti(2012), Sakah et al.(2017), Polzin et al. (2019) have highlighted the importance of energy policy and financial support in levelling the playing field and reducing the risks associated with the investment decision. Overall, findings showed that respondents placed more value in the attributes that guaranteed their returns rather than the return itself. Studies by Clark-Murphy and Soutar (2004) and Aguilar and Cai (2010) also find that although investors highly value the rate of return, it is often not the most important attribute in renewable energy investments as shown in this study.

A positive WTP for a developer of domestic origin also hints on the importance of trust, credibility and some level of familiarity as found in a large section of finance and investment literature. The many explanations for “home biased” investments or preference for domestic project development companies include the assumption of the ease of obtaining information and knowledge compared to international firms/companies as seen in Brennan and Cao (1997), Zhu (2002), Barbar and Odean (2011) and Oehler *et al.* (2017). Though “home bias” is often discussed as a less optimal occurrence in investment literature, it should be considered a positive signal to build the expertise of local renewable project developers as this is more likely to produce more significant synergistic effects in building a sustainable local energy ecosystem.

Evidently, some respondents show satiation (that is, where an individual has no further interest in an attribute once a specific level has been achieved) with respect to the highest level of project viability and track record. Scott (2002) explains this as target setting behaviour, like the Tversky’s “elimination of aspects” model (Tversky, 1972a; Tversky, 1972b) and Simon (1959) satisficing model. Because of this, the highest marginal willingness to pay was obtained for a level lower than the highest levels of track record and project viability presented in this study. It is worth considering though that the levels with the highest WTP values reflect rather satisfactory conditions in real situations.

The findings also demonstrate the heterogeneity in preferences for attributes among classes with members of class 2 being the typical status quo lovers or return chasers. Members of class 3 by their preferences exhibit characteristics similar to what is known about investors in renewable energy. For example, studies show that the renewable energy investor is usually risk-averse, requires support and has lower profit expectations(Enzenberger *et al.,* 2003; Dinica,2006; Couture and Gagnon, 2010). This makes them unique as their needs are generally not fully satisfied by the general policy support instruments. Simply put, citizen energy groups may require some bespoke support systems, and often jurisdictions that seek to advance investments from these groups provide them.

On demographics, being young (18 -34) was the only factor influencing the likelihood of investing in the RE investment. Studies on how age affects attitudes toward green energy (including investing) have been mixed at best (Borchers et al., 2007; Zarnikau, 2003; Mahaptra and Gustavvson, 2008; Mills and Schleich, 2012; and Kostakis and Sardianou, 2012). This finding is however consistent with previous studies that show that persons up to 35 years are considered more than likely than other counterparts to invest in RE or as age increases the likelihood of investing decreases (Aquilar and Cai, 2010; Gamel et *al*. 2016). The effect of higher education(masters and above) was not found to influence investment in this study as the reference for comparison were degree holders unlike in other general consumer studies that compare degree and non-degree holders. People in the lowest income group were the least likely to invest in renewable energy as they have the most negative preference. This finding for people in the base income category is not surprising as access to credit is crucial for investment, and these respondents may have less disposable income for investment.

On technology preference, this study confirms numerous prior research that suggests that solar PV is preferred over other renewable energy sources for investment (see Borchers *et al.,* 2007 and Gracia *et al.* 2012). Solar energy came up tops in the focus groups conducted in Ghana and the reasons for the belief in the technology according to participants were positive experiences with use (many participants stated they owned small solar gadgets like torches and lamps) and *a priori* knowledge

5 Conclusions and recommendations

With just a decade to 2030, efforts towards universal electricity access must embrace an all-hands on -deck approach to financing for renewable energy in SSA. This paper considers the role that households or citizens can play in the renewable energy financing space and seeks to understand their preferences by determining household investor willingness to pay for different renewable energy investment attributes including assessing preference heterogeneity, choice of renewable energy technology and investing style.

This paper has shown that there is a section of household investors that are fit the criteria for potential investors in renewable energy. Specifically, the findings show the importance attached to a local project developer with a good track record. This suggests that building local technical expertise is crucial for attracting citizen investment in renewable energy. Again, the study highlights the importance of the energy policy and support environment for eliminating the risks that investors associate with investing in RE. What this means is that government and policymakers in designing policies that attract citizen investment must develop initiatives that build the skills, technical expertise and track record of domestic project developers. This can be done by providing training and opportunities for local developers to gain relevant experience. On the issue of policy support systems, policymakers must endeavour to provide a stable policy environment and support systems that reduce the risks associated with RE investments. Support systems like feed-in-tariffs and investment subsidies and grants are necessary for enhancing the profitability of renewable energy investments. They should be employed to ensure that investors are duly rewarded for the associated risks.

On the influence of demographics, the study found that young people (18-34 years) are more likely to invest than other counterparts. Thus, initiatives towards engaging young people will help in attracting RE financing. Again, the heterogeneity of household investors suggests that to attract investment from large sections of the population successfully, household investors must be engaged to understand their diverse needs and motivations further, as shown in the heterogeneity in preference for attributes.

Lastly, like any other research, this study is subject to some limitations. Perhaps, one of the fundamental limitations of this work was the limited budget which constrained the sample size. Had the budget allowed, the study would have reached for a much higher sample size to ensure the generalizability of findings. With no known citizen-funded renewable energy projects in the country, use of revealed preference to validate findings may not be immediately possible however assessment of household investor preference in other country in SSA will be useful in advancing knowledge in this area.

Finally, because there is a limit to how many attributes can be incorporated into a choice experiment, (see Johnson *et al.* 2013), other unobserved attributes and factors could have affected the results although a thorough literature review and interviews were used to ascertain the relevance of attributes used. For future research, studies could investigate the highest sums that respondent are most likely to invest to gauge how much investment can be leveraged for renewable energy investments from household investors.

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