Analysis of latent impeding factors to solar photovoltaic investments in Ghana

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Abstract

Purpose – Ghana has recently reviewed its renewable energy Act 835 with an objective of providing 10% of its energy from renewables by 2020 (Ackah and Asomani, 2015). Meanwhile, solar Photovoltaic (PV) accounts for less than 2% of the energy mix (Energy Commission, 2018). In combating environmental issues such as climate change and meeting these policy targets, there is the urgent need to increase investment into the renewable sector. Therefore, the purpose of this paper is to critically examine the impeding constraints to photovoltaic investment in Ghana.

Design/methodology/approach – The Literature evaluation was carried out of critical constraints surrounding PV investments. Questionnaire was developed and administered online using Google form. Descriptive statistics was used to describe the features of each constraint. In addition, inferential analysis using relative importance index was used to rank these indicators. Again, one sample *t*-test was used to test the significance of the indicator. Multiple indicators were used to measure the latent constructs. Finally, independent test of mean equity was used to test relationship between the working experiences of despondence who have worked with solar PV below five years and those who worked from five years to ten years.

Findings – The research has highlights high installation and maintenance costs, lack of access to long-term capital finance, access to affordable consumer finance and lack of support to research and development as the major investment obstacles to solar PV investment in Ghana.

Research limitations/implications – It is recommended that the Government of Ghana should provide incentives such as tax waivers, which will encourage entrepreneurs, invest into PV. In addition, it is recommended that solar PV companies must collaborate with financial institutions to provide low interest and flexible consumer financing schemed that can enable home users to purchase the technology. Future research should complement this work by focusing on the impact of domestic currency volatility on PV investment. The scope of this study is constrained to the PV industry in Ghana.

Practical implications – This study will serve as a guide to the private sector business owners to help make critical PV investment decisions. It has also brought to the forefront the reason why solar PV account for a small fraction of Ghana's energy mix.

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Originality/value – This paper seeks to espouse the prevailing constraints to PV investment in Ghana and seeks to contribute to already existing literature that will make profound changes in state policy around PV investment. By understanding these difficulties, driving pointers can be recognized to encourage effective future venture inside the sustainable power source area. In this way, the research leads to a better understanding of the impeding factors that hinders PV investment in Ghana. Again, the paper has achieved new discovery with regards to variations between years of experience with PV use. The variation being less than five years with over five years of PV use. By understanding these difficulties, driving pointers can be recognized to invigorate effective future ventures.

Keywords Decision-making, Interviews, Surveys, Entrepreneurs, Energy sector, Renewable energies, Photovoltaic, Consumer financing

Paper type Research paper

1. Introduction

It is clear that Ghana is visibly blessed with abundant renewable energy (RE) resources comprising solar, wind, biomass and hydro. Expanded investment in these sustainable power sources has been recognized as a planned answer for the intermittent power supply in Ghana. Recently, a RE Act 835 (2011) has been affirmed which has an objective of 10 per cent of RE share in Ghana's energy blend by 2020 (Ackah and Asomani, 2015).

Gail *et al.* (2011) state that energy security is a key policy, which needs a multi-faceted measure to tackle it. In the midst of all these energy challenges and uncertainties, solar energy seems to be the game changer because its tariff is more economical than conventional generation (Jeremy *et al.*, 2015). Not only is solar photovoltaic (PV) cheap, it also has numerous carbon benefits (Fionnuala and Kevin, 2017). Furthermore, Muhammad (2016) states that, sustainable power source is comprehensively thought to be reasonable answer to address energy and environmental issues around the world. Oyedepo (2012) further stated its benefits, which include a general and profusely realistic asset base, ecological cordiality and diminishing price patterns.

In the course of the most recent few decades, sustainable power source has encountered an expedient advancement over the world (Jeremy *et al.*, 2015). Available insights show that inexhaustible technologies have now surpassed petroleum product based innovations as far as yearly limit expansion at the worldwide level (Muhammad, 2016). According to María and Pablo (2013), several measures have been adopted in the European Union (EU) to enhance and promote PV. Countries have adopted measures to promote PV and it can provide roughly 2.6 per cent of the electricity. PV technology has been the most suitable technology to meet the energy demands of off-grid communities because of the request for low power electrification (Almeida and Brito, 2015) typically around 1 to 5 kilowatt peak (kWp) in size. Among other off-grid applications, PV is further used in non-domestic applications such as health centers, schools, telecommunication, water pumping and navigational aids (Dajuma *et al.*, 2016).

According to Eshun and Amoako-Tuffour (2016), Ghana occupies the 114th position in the nature of power supply and scores 3.0 beneath the word's mean normal of 4.5 regarding adequacy and unwavering quality of power.

Power emergency has turned into a constant formative obstruction in Ghana, with swelling seriousness that undermines the nation's financial development and improvement. Danso-Wiredu *et al.* (2016) concluded that in 2014 Ghana lost between $320m and $924m because of the power crisis, amounting to between two and six per cent of the country's annual gross domestic product. Wolde-Rufael (2006) posited that Ghana required an average capacity of somewhere in the range of 16,398-17,350 GWh. This converts into further capacity requirements of 4000- 4200 MW to meet the demand. Eshun and Amoako-Tuffour (2016)

reviewed the trend of PV in Ghana and found out that, the share of renewable in the generation mix is less than five per cent. Obeng and Evers (2009) explored solar PV electrification and energy poverty and also found out that, solar PV is a key energy source in achieving sustainability in the energy supply.

Despite the growth in solar PV worldwide and its importance to development, published empirical research on the topic has been limited. To bridge this research gap, there is a need for more research that furthers our understanding on solar PV investment. The objectives of this paper are three-fold. First, to advance our understanding on climate change the need for solar PV integration into our energy mix for climate action. Second, to deepen our understanding on the challenge of solar PV investments. Furthermore, PV investments trend in Africa and Ghana is also presented.

While there have been comparative research on challenges to renewable energy transfer (RET) to Africa (Edem *et al.*, 2015), there has been very limited research on key constrains to PV investments in Ghana. This study is an attempt to fulfill that gap by focusing on the principal barricading factors to solar PV investments in Ghana. It is expected that findings of the study would enhance the overall understanding of impeding factors to PV investment in Ghana. The study has been restricted to the PV sector in Ghana.

The rest of the paper is structured as follows. Section 2 provides literature review of climate change and the need for solar photovoltaic investments, followed by an understanding of the constraints of solar photovoltaic investments, and trends of solar photovoltaic investments: globally, Africa and Ghana. Section 3 describes the methodology and data sources. Data analysis and discussion were outlined in section 4. Section 5 presents the outcomes, contributions and implications. Finally, conclusion and remarks were discuss in Section 6.

1.1 Climate change and the need for solar photovoltaic investments

Fossil fuels consumption causes environmental challenges and contributes considerably to greenhouse gases (GHGs) emission that negatively impact the climate (Dajuma *et al.*, 2016). Again, it is worth noted that in relating to climate change, anthropogenic GHG emissions are mostly driven by population size, economic activity, lifestyle, energy use, land-use patterns, technology and climate policy (Momodu *et al.*, 2017).

According to Catellani *et al.* (2019), the impacts of global warming of 1.5°C above pre-industrial levels established that very little time remained to keep global warming below this threshold. Any further increase above that point would significantly intensify the risk of life-threatening climate events, such as drought, floods and very extreme temperatures for much of the world's population (REN21, 2019).

In addition, the annual review of UN Sustainable Development Goal 7 (SDG7) cited by REN21 (2019), established that, the purposes for renewables and energy access set out for 2030 under SDG7 will not be achieved unless efforts are tremendously scaled up.

The renewable energy market has seen rapid growth during the past few years with investment in clean energy assets (not including large hydro) being $29.5bn in the first quarter of 2010, 63 per cent above that in the same period of 2009. The global capacity of many renewable technologies increased at rates of 10-60 per cent annually during the period from the end of 2004 through 2009 (Lu and Davison, 2013).

Environmental change moderation arrangements and exercises help bolster sustainable power source advancement, including solar-based energy. A few motivating forces and commands intended to actuate GHG alleviation have empowered sun-based energy in industrialized nations (Pawłat and Stryczewska, 2011). Laumanns *et al.* (2004) and

Radulovic (2005) posited that, an enhanced arrangement and use of these sustainable power source innovation could make impressive advantages for the entire world.

In the views of Oyedepo (2012), worldwide energy utilization is probably going to become quicker than the expansion in population. Realizing the increase in energy consumption, government needs to continuously review its energy policy to ensure long-term reliability and security of energy supply. Michael and Wisdom (2017) state that an effective and sustainable energy policy has two main considerations. The first consideration is to increase access to affordable, modern energy services, and the other to find the mix of energy resources and technologies that will reduce the adverse environmental impacts and to maintain sustainable development.

1.2 Understanding the constraints of solar photovoltaic investments

Impeding factors towards a full-scale shift to renewable PV energy in developing countries lie not just in technology costs but also in the difficulties of securing long-term reasonable finance (Quansah *et al.*, 2016). Nevertheless, a number of constrains (Iwasaki and Yamamoto, 2014) hinder the smooth implementation of these policies and adoption of the PV technology. From the literature, review conducted various prospective factors were identified. These factors are:

1.2.1 Access to long-term capital finance. Even though financial mechanisms such as equity finance, venture capital (VC) fund, debt financing and crowd financing among others are available to financiers, most of them are not fully developed in Ghana (Yi *et al.*, 2013). For instance, crowd financing is not completely developed in Ghana and hence not available to entrepreneurs. Equity finance is also not very widespread in Ghana (Bensah *et al.*, 2017). The only financial instrument available to Ghanaian entrepreneurs is possibly debt finance.

1.2.2 Cost of high finance interest rate. Since most project financiers prefer debt financing to other forms of financing, cost of finance plays a very significant role in decision-making regarding whether to access funding from banks or from other means. Currently, the base rates of most banks are above 30 per cent making cost of borrowing very expensive in Ghana (Bensah *et al.*, 2017).

Kemfert and Schäfer (2012) state, financial obstacles such as low equity return rates considering the risk that originates with investments in RETs exacerbate the financing framework for PVs. Especially newly developed technologies are confronted with this obstacle, as the chances of success and potential for profit are difficult to assess for external financiers who often lack the appropriate information and understanding to conduct sufficient project risk valuation (Masini and Menichetti, 2012).

Furthermore, Quansah *et al.* (2016) reveal that the overall absence of investment support and long-term, low interest rate credit as pertains elsewhere suggests that PV projects have to be equity financed and most often paid for prior to installations. The alternative is to finance with short-term, high interest loans, with rates as high as 30 per cent p.a. Hellmann and Puri (2002) has shown that VC-backed firms play an important role in commercializing breakthrough technologies.

1.2.3 Business climate (currency fluctuations). A number of factors go into the determination of business climate, however, currency instabilities has been highlighted because of its distinctive role in Ghana's economy. An incessantly weak currency increases the cost of imports (Ping *et al.*, 2018). Alagidede and Ibrahim (2017) conclude that the Ghana Cedi has depreciated against major currencies especially the US Dollar (US$) as it recorded little stability between 2002 and 2007. Certainly, the level of depreciation contributed to a rise in consumer price inflation from 13.8 per cent in January 2014 to 17 per cent in December 2014.

1.2.4 Market obstructions. Djokoto *et al.* (2014) additionally distinguished absence of market request as a key boundary to economical PV development in Ghana. Grid expansion to rural Ghana is one of the key drivers of the low dissemination of PV in contrast with Kenya and Zimbabwe (Quansah *et al.*, 2016). Different parts of Ghanaian government energy strategies that have driven the low spread of PV in Ghana are the import obligations on PV segments and the high levies on PV frameworks versus the national grid (Bensah *et al.*, 2017). Whiles grid clients in Ghana gain from tax sponsorship, PV clients do not, which drives many individuals to crave for the grid (Ping *et al.*, 2018).

Various market related factors such as underdeveloped supply chain, small market size, unstable market situation, failed past experience and lack of successful reference projects hampers PV development in Ghana (Bensah *et al.*, 2017). Market outlook such as uncertainties regarding governmental renewable energy strategy and targets, market access and price limitations, liberalization uncertainty related to access and market distortions such as high fossil fuel subsidies has made PV investment unattractive (Hagan, 2015).

1.2.5 Technical hindrances. Various limitations exist for renewable energy technologies. Williams and Dair (2007) in their research identified the lack of adequate expertise in the form of technicians and engineers in Ghana to design heavy-duty solar projects. Low project management skills, especially at the local level, was also identified as one of the key challenges affecting the mass dissemination of PV projects (Bawakyillenuo, 2008).

1.2.6 Inadequate training centers. Presently there are only few PV training centers in the country primarily located in Accra and Kumasi. The attention of all the training centers is mainly focused on solar PV systems design, installation and maintenance but it's not adequate to meet the market demands let alone targets set under the Ghana renewable energy policy (Bensah *et al.*, 2017). According to Abdullahi *et al.* (2017), aside from insight, the staff to assist with specialized expertise to install the solar panels is inadequate.

1.3 Trends of solar photovoltaic investments: globally, Africa and Ghana

According to REN21 (2019) report, the projected share of renewables in global electricity generation was more than 26 per cent by the end of 2018 with renewable share now making more than one-third of global-installed power capacity. With regards to power generation, renewables have accounted for more than half of all global capacity additions since 2012 (Gielen *et al.*, 2019).

According to the World Bank group (2018) cited by REN21 (2019), announced a target of investing USD$200bn over five year period starting from 2021 to support 35 gigawatts (GW) of renewable energy infrastructure in Asia and Africa. Furthermore, from 2010 most of the investment has been directed toward off-grid electricity companies operating in Africa, with East Africa accounting for 58 per cent of the investment mobilized, West Africa for 17 per cent and Southern Africa for 4 per cent (OECD/IEA, 2018).

Electricity from renewable energy sources in the EU rose by eight per cent and by six per cent in Japan and India (Jäger-Waldau, 2017). The International Energy Agency also indicated that the growth in renewables is not only in the power sector but also in the use of renewables to provide heat and mobility also increased worldwide, albeit from low base.

Many emerging economies have an extraordinary solar based asset and have actualized approaches to support the improvement of the solar based industry to understand the advantages that extended utilization of PV innovation can have on their economies and on enhancing energy security (Muneer *et al.*, 2011).

The plan to scale up RE investment in Ghana was first developed by the Ministry of Energy under the scaling-up renewable energy program in Ghana (SREP) in 2015 to increase

investment in the RE subsector. This was also to enable the Government's strategy to unlock financing opportunities by fast-tracking the development of RE (Sakah *et al.*, 2017).

The Power Ministry sets targets on renewable energy projects by 2020, under the SREP. The development of RE projects has seen tremendous improvement in Ghana over the years possible because of the presence of RE legislations and policies.

2. Methodology

The research adopted a deductive methodological approach to prove hypothesis arising from the extant literature using quantitative method. Primary data were gathered using survey questionnaire. Survey was adopted because it improves consistency of interpretations and enhances replication because of the inherent standardized measurement and sampling techniques (Oppenheim, 2000).

Admittedly, it may not be possible to identify the exact population hence a theoretical sample was used. Because there was no sampling frame for this study, the sample was a non-probability. The sampling technique adopted in relation to its design, purpose and realistic inference on this research topic is purposive sampling. Purposive sampling is very convenient when a researcher needs to quickly contact a targeted sample (Tongco, 2007). According to Singh and Masuku (2014), purposive sampling is suitable when a completely random sampling method cannot be used to select respondents from the whole population. The purposive sampling was used in getting the sample size because of the challenges encountered in evaluating the population size. The process was used to get a representative sample size of government agencies, consultancy firms and PV installation companies and banks.

Despite the fact that the sample size was generally small, measurable examinations could at present be performed on the grounds of the central limit theorem (Ott and Longnecker, 2010; Hwang *et al.*, 2015).

The design questionnaire was pre-tested amongst four potential respondents before administering them. According to Asiedu and Alfen (2015), the organization and language used in drafting the survey instrument should take into consideration the target respondents considering its general appeal and ease of reading.

The three-page questionnaire divided into two sections and was administered to 80 respondents comprising 39 technical experts from utility companies. About 27 individual investors and 14 from policy institutions comprising Non-Governmental Agencies (NGOs) and international development agencies. We received 47 responses of which 24 was from technical experts. A total of (a-51.06 per cent response rate of this group), 17 from investors (b-36.17 per cent response rate) and 6 from policy institutions (c-12.77 per cent response rate). While the sample size is small in total numbers it provide a very good coverage of technical experts. The quality of the sample is underline by the participant with an average industry experience between 5 and 15 years.

Respondents were from the Ministry of Energy, Volta River Authority, Energy Commission, PV installation and consulting firms, Electricity Company of Ghana, International Development Agencies such as United States Agency for International Development, NGOs. As per Hallowell and Gambatese (2009), evaluating the profile of the respondents particularly the long periods of involvement of experience is observed as critical factors in knowing the skill of respondents.

These respondents were chosen because according to Bensah *et al.* (2017) the involvement of these stakeholders is critical. They play different and harmonizing roles from policy formulation and enactment at the national and local levels.

Descriptive (mean and standard deviations) and inferential (relative importance indeces and one-sample *t*-test) techniques were used to analyze the data. According to Ryan (2004), descriptive statistics helps in the simple understanding of enormous amounts of data, and offers a chance to relate the research findings to people, while inferential statistics predominantly helps to deduce inferences (Baddie and Halley, 1995; Kolawole, 2001).

3. Data analysis and discussion

3.1 Reliability test

The study used multiple indicators to measure the latent variables (constructs); obstacles to solar PV investment. The reliability level of the indicators to the constructs was investigated and the results presented in Table I below. The results showed that there is high internal consistency of the measurement indicators, since the Cronbach's alpha values were greater than the cut-off point, 0.70. This means that the indicators measured their respective constructs, demonstrating high level of reliability.

3.2 Prevailing impeding factors to solar photovoltaic investments in Ghana

Challenges confronting solar PV investment were examined in this section of the analysis. The study used descriptive statistics (mean and standard deviation). Inferential analysis of relative importance index and one sample *t*-test. The descriptive statistics was used to describe how each of the indicators was considered on average as barrier. Index was used to rank the indicators from the highest barrier to the least barrier. One sample *t*-test (Table II) was used to test the significance of the indicator (Tables II to IV).

Constructs	No. of items	Cronbach's alpha	
Constraints to PV investments	12	0.787	Reliable

Source: Sackey (2018)

Table I. Reliability test

Constraints to PV investments	*N*	Mean	SD	Index	Ranking
High installation and maintenance costs	47	3.98	1.011	79.6	1
Lack of access to long-term capital finance	47	3.66	1.166	73.2	2
Lack of access to affordable consumer finance	47	3.60	1.116	71.9	3
Lack of support to research and development	47	3.51	1.177	70.2	4
Lack of good business climate (currency fluctuations)	47	3.17	1.129	63.4	5
Unsustainable government policies	47	3.09	1.039	61.7	6
Lack of understanding of the benefit of solar	47	3.06	1.451	61.3	7
Lack of attractive tariff for solar power generation	47	2.94	1.169	58.7	8
Lack of quality solar installation materials	47	2.92	1.231	58.3	9
Lack of trained personnel for installation	47	2.83	1.324	56.6	10
Lack of laws on Solar PV installation standard	47	2.68	1.236	53.6	11
Frequent failure of installed equipment	47	2.49	1.266	49.8	12
Politicization of consumer interventions	47	2.32	1.144	46.4	13

Source: Sackey (2018)

Table II. Descriptive statistics of impeding factors to solar PV investment

Constraints to PV investments	*t*	df	*p*-value	Level
Politicization of consumer interventions	−4.080	46	0.999	Not significant
Lack of good business climate (currency fluctuations)	1.034	46	0.153	Not significant
Lack of trained personnel for installation	−0.881	46	0.809	Not significant
Lack of laws on Solar PV installation standard	−1.771	46	0.958	Not significant
Lack of attractive tariff for solar power generation	−0.374	46	0.645	Not significant
Lack of access to long-term capital finance	3.878	46	0.000	Significant
Lack of understanding of the benefit of solar	0.302	46	0.382	Not significant
High installation and maintenance costs	6.640	46	0.000	Significant
Frequent failure of installed equipment	−2.765	46	0.996	Not significant
Lack of access to affordable consumer finance	3.659	46	0.000	Significant
Unsustainable government policies	0.562	46	0.289	Not significant
Lack of quality solar installation materials	−0.474	46	0.681	Not significant
Lack of support to research and development	2.974	46	0.002	Significant

Notes: Test-value: mu = 3.0; alternative: mu > 3.0
Source: Sackey (2018)

Table III.
Constraints to PV investment

From Table IV, the test result showed there was insignificant difference between the mean values of the respondents who have worked with solar PV below five years compared to those that worked between five and ten years. All the impeding factors were identified to be determined by all levels of experience; below five years and 5-10 years, *p*-values of the *t*-test for the equality of mean > 0.05 showing no significant difference. The four most significant constraint identified in the study (Table III); were lack of access to long-term capital finance, high installation and maintenance costs, lack of access to affordable consumer finance and lack of support to research and development were determined by all levels of experience depicting significant issue.

Furthermore, the study identified four extreme impeding factors in the results; the first four ranked in Table II. The high installation and maintenance cost of solar PV investment was found as the highest impeding factor in the study. This supports the findings by Bensah *et al.* (2017) and Quansah *et al.* (2016) that established economic barrier of solar PV investment to be associated with high upfront costs. The mean score observed in the study (Table II) was 3.98 with variability of 1.011 and index for ranking of 79.6 per cent showing extreme impeding factor in Table II.

Lack of access to long-term capital finance was the second identified constraint with mean score 3.66 and standard deviation of 1.166 signifying the respondents.

The third impeding factor was lack of access to affordable consumer finance. The mean score recorded was 3.60 with standard deviation of 1.116. Lack of support to research and development was the fourth ranked factor recording a mean score of 3.51 with standard deviation of 1.177 (index of 70.20 per cent). All the mean quantities for the elements in the table were over the population mean (3.5). It very may be deduced that each one of these elements is huge (to the extent boundaries to PV appropriation is concerned).

According to Bensah *et al.* (2017) and Quansah *et al.* (2016), economic constrains are usually associated with high upfront costs and high interest rate. Koinegg *et al.* (2013) posited that the appearing cost of PV infrastructure is a major obstacle to its implementation. Edem *et al.* (2015), investigated barriers to RET to Ghana, and concluded that technical, socio-cultural, legal and regulatory are some of the obstructions to Solar PV investment in Ghana. The research affirms the findings of all these literatures.

Constraints to PV investments	Years of experience with solar (PV)				Independence test of mean equality					
	Below 5 years ($N = 37$)		6-10 years ($N = 10$)		Levene's test for equality of var		*t*-test for equality of means			
	Mean	Std. err. mean	Mean	Std. err. mean	*F*	*p*-value	*t* (df)	*p*-value	Mean diff.	Std. err of mean diff.
Politicization of consumer interventions	2.43	0.184	1.90	0.379	0.445	0.508	1.316	0.195	0.53	0.405
Lack of good business climate (currency fluctuations)	3.22	0.182	3.00	0.394	0.213	0.647	0.533	0.597	0.22	0.406
Lack of trained personnel for installation	2.76	0.210	3.10	0.482	0.119	0.731	−0.724	0.473	−0.34	0.474
Lack of laws on Solar PV installation standard	2.76	0.203	2.40	0.400	0.156	0.694	0.807	0.424	0.36	0.442
Lack of attractive tariff for solar power generation	3.08	0.179	2.40	0.427	0.621	0.435	1.667	0.103	0.68	0.409
Lack of access to long-term capital finance	3.62	0.191	3.80	0.389	0.139	0.711	−0.425	0.673	−0.18	0.419
Lack of understanding of the benefit of solar	3.11	0.235	2.90	0.504	0.102	0.751	0.399	0.692	0.21	0.522
High installation and maintenance costs	4.03	0.157	3.80	0.389	2.436	0.126	0.626	0.534	0.23	0.363
Frequent failure of installed equipment	2.32	0.194	3.10	0.458	0.27	0.606	−1.757	0.086	−0.78	0.441
Lack of access to affordable consumer finance	3.62	0.161	3.50	0.500	5.284	0.026	0.303	0.764	0.12	0.402
Unsustainable government policies	3.22	0.170	2.60	0.306	0.21	0.649	1.698	0.096	0.62	0.363
Lack of quality solar installation materials	2.84	0.200	3.20	0.416	0.034	0.854	−0.823	0.415	−0.36	0.440
Lack of support to research and development	3.43	0.184	3.80	0.442	0.387	0.537	−0.874	0.387	−0.37	0.421

Table IV.
Variations between years of experience with solar PV and their determinant of constraints

The following impeding factors to solar PV investment were ranked as moderate on average; lack of good business climate (currency fluctuations), unsustainable government policies and lack of understanding of the benefit of solar. Table III showed the significance test for the indicators of constraints to solar PV investment (on each indicator). The results revealed lack of access to long-term capital finance, high installation and maintenance costs, lack of access to affordable consumer finance, lack of support to research and development were statistically significant to solar PV investment. The p-values of these constraints were less than 0.05 and the t-values were greater than 2; the positive indicating the mean scores were significantly higher (showing extreme difficulty with mean scores greater than 3.5).

The remaining impeding factors had their standard deviation less than one, showing that there exists consistency in assertion between respondents' elucidations. This is most likely in light of the fact that the respondents comprehended these variables exceptionally well. In addition, each one of the impeding factors had their means greater than the hypothesized mean of 3.5 and their standard error means were additionally near zero demonstrating that there was incredible consistency among understanding between the respondents.

4. Outcomes, contributions and implications

First, this study confirms that high installation and maintenance cost, lack of access to long-term capital, lack of access to consumer finance and lack of support to research and development are the prominent impeding factors to PV investment in Ghana. In particular, it can be considered as a basis for a better understanding of the investment issues that affect solar PV infrastructure. Previous works have focused on the barriers to renewable technology transfers to Ghana. In addition, this study may help international investors, financial institutions and entrepreneurs to gain understandings on a project conditions and investment environments that may facilitate high debt leverages with positive effects on project selection processes. The study examined the latent impeding factors to PV investment in Ghana and established why PV accounts for less than five per cent of Ghana's energy mix. This work originates from both practical and theoretical inferences. From a theoretical perspective, this work covers the literature on the topic, which explains the issues being investigated from a quantitative perspective. From a practical point of view, this work will serve as a guide for government to make major policy decision on stimulating renewable energy investment.

5. Conclusion

In a global context, government prioritization of capital flows for infrastructure projects remains weak in most developing countries. Moreover, where major infrastructure policies have been adopted, budget allocations have been unsatisfactory to meet rising demand.

The objective of this research was to fortify our understanding of solar PV investment and its role in increasing RE development in Ghana. The analysis and findings of this study have substantially contributed toward achieving this objective. Results indicated high installation and maintenance cost, lack of access to long-term capital, lack of access to consumer finance and lack of support to research and development were found to be prominent impeding factors to PV investment.

By understanding these challenges, leading pointers can be identified to stimulate successful future investment within the RE sector. Clearly, the lack of access to long-term capital and lack of access to consumer finance has been the greatest constrains for PV investment. The challenge remains as to how governments can find creative ways such as removal of huge import duties that are imposed on PV materials in a form of tax waivers. This will encourage entrepreneurs to invest into PV. The Ghanaian economy is capable of

rising to these financing and investment challenges but implementation of appropriate policies will be an essential ingredient for success (Badu *et al.*, 2012). In addition, government must collaborate with financial institutions to provide low interest and long-term consumer financing models for PV investment. Government must collaborate with the private sector to strengthen research and development (R&D).

Further research designed to explore the impact of government policy interventions in the PV industry in Ghana will significantly add to this growing body of knowledge.

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