A QUALITATIVE STUDY ON SOLAR ENERGY USE IN SOUTH AFRICA

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Abstract

Many South African citizens and residents are dependent on Eskom for electricity distribution. Its' limited energy distribution and its' ever increasing cost has taken its toll on the consumers. The citizens might be motivated to adopt solar energy technology to circumvent this problem. It is therefore imperative to establish, additional information that warrants investment in solar energy technology. Furthermore, it is imperative that consumers are presented with a database of information to the efficiency of solar power in households who have already implemented solar energy technology. It can therefore be suggested that there is paucity of research in South Africa in relation to challenges and benefits of using solar energy. In this regard a study was conducted in Gauteng province, in the city of Johannesburg, in South Africa to fill this gaps. The data was collected using semi-structured interviews. The target population for the current study were the suburban households which had solar photovoltaic (PV) and solar water heaters (SWHs) installation. A total number of 15 respondents were interviewed. The data was analysed using Tesch's open coding approach. The findings suggest that these Johannesburg suburban households shared similar positive experiences and negative experiences from the use of solar energy systems. The findings suggest that the use of solar energy saved on electricity. However they experienced water leakage from their geysers. The findings from this qualitative research is of particular importance to the South African households who are considering an alternative solar energy supply.

Keywords: Gauteng, Households, Photovoltaic Systems, Solar Water Heaters

Introduction

South Africa has the national grid as the main source of electricity supply. However, its' supply has been inconsistent. The country has experienced a number of power cuts in the period 2013 to 2015. In the beginning of the second decade of its democracy, South Africa has witnessed many other countries beginning to move out of the grid supply to a world of renewable

energy. Majority of the electricity in South Africa is generated from non-renewable energy in the form of coal. Therefore, making use of electrical copper cables for power transmission. However, the efficient supply of electricity is stifled by cable theft and illegal connections by its populace.

The world has swiftly moved into alternative source of power, the sun because the solar power is clean and is known to be an environmentally friendly source of energy (Veeraboina and Ratman, 2012). According to Lewis (2007) the same energy consumed by humans in an entire year, is received by the earth in an hour. Therefore, the sun has the capacity to supply enough energy.

Shinwari, Ali and Neyyar (2004) noted that solar power also known as photovoltaic power has very little negative impact on the environment thus making it one of the cleanest sources available to mankind for power generation. The residential sector derives most of its energy from the electrical grid prior to installing photovoltaic panels (Bauner and Crago, 2013).

The decision to invest in solar system which is also known as photovoltaic system as an alternative option for electricity supply is supported by the consistency of hot water from the solar geyser. This is one of the reasons that make renewable energy attractive. However, solar energy creates uncertainty to the end-user about the prospects of fully committing to such an intensive investment to adopt solar energy technology. The cost of renewable energy and more efficient batteries continue to decline and as a result these attributes have made solar energy technology to be amongst the desired alternatives (BCA Research, 2015). Based on this discussion, the world has witnessed a growing demand on renewable energy which has led to the residential sector searching for alternative energy, such as solar, wind and hydro in order to provide all or part of the required electricity supply.

Problem Statement

The oversight from the South African government in terms of planning for the provision of adequate energy has jeopardised the productivity of the business fraternity as well as the South African household’s provision of electricity. Concerns towards the electricity crisis and lack of sufficient generation capacity by Eskom is likely to continue for an unforeseeable future because of unstable electricity supply. However, majority of the citizens are reliant on the national grid for power supply. It can be stated unequivocally that the country has got an abundance of sunshine and one would question, why it is not utilised. Hence, the researcher wants to find out the practicality of using solar photovoltaic system and solar water heater to the people who have already installed the solar energy technology and what they think about it. Based on the

background to the problem, this study is guided by two specific research questions: viz;

i. What are the benefits of using solar power in the South African households?; and
ii. What are the challenges facing the South African households in relation to the use of solar energy?

The specific research objectives guiding this study are:

i. To determine the benefits of using solar power in South Africa households; and
ii. To determine the challenges faced by the South African households using the solar energy.

Literature Review

Solar Power Principles and the System Structure

According to Breeze (2014) solar energy is seen as an ultimate renewable energy almost all over the world. The solar energy also known as photovoltaic energy is generated from a state of direct radiation from the sunlight that reaches the earth's surface. Sadhishkumar and Balusamy (2014) opined that solar energy systems need to collect more energy for direct use. Shinwari, Ali and Nayyar, (2004) indicated that solar power is guaranteed when the sunlight is converted into energy by the solar cells known as photovoltaic.

The configuration of the photovoltaic cells is that the current in the cells is direct current (DC) of which is able to be converted by an inverter into alternating current (AC) which is usable electricity voltage in the house (Elnokaly and Martin, 2014). According to Mohandes, El-Chaar and Lamont (2009), these photovoltaic cells are interconnected together, covered either in a weather proof covering in a structure of a glass or in a plastic laminar identified as a block plate. All these cells have a mandate to convert solar energy into direct current.

However, in order for the photovoltaic energy to be generated the structure according to Aman *et al.*, (2015) and Stampolidis, Katsigiannis and Georgilakis (2006), should consist of photovoltaic modules or panels. These are units that are readily pre-structured, ready to be installed. These solar modules are formed by cells connected together. It is important that clients which to install the solar energy system understand its structure and principles.

Benefits of using Solar Energy as a Source of Energy

Payback Period: A Return on Investment

Faiers, Cook and Neame (2007) defined the payback period as the grace period before the return on the original investment is accrued. According to European Photovoltaic Industry Association (2015) the estimated return on investment is payback period for adopters of photovoltaic system. In addition, Mukai, Kawamoto, Ueda, Saijo and Abe, (2011) stated that once the end-user has been satisfied regarding the solar power performance, additional environmental factors and status operating as well as the generation condition will be brought to attention.

A research undertaken by Mohammad-Sukki *et al.*, (2012) substantiates that the payback period, 10 years, was considerably shorter than the expected and guaranteed 30 years lifetime of the installation. The findings from the study indicated that for rooftop system and facade systems, the payback period ranges from 3 to 4 years. Batidzirai, Lysen, van Egmond, and van Sark, (2009) affirm that for a high-income household, the payback period in SWH systems is just over 4 years but the SHW system may vary from place to place (Chow, Fong, Chan, and Lin, 2006).

Challenges of using solar energy as a source of energy

Environmental Condition

Nieuwoudt and Mathews (2005) emphasised that selecting a solar heating system must have appropriate environmental conditions. Hence, according to Veeraboina and Ratnam (2012) temperature of 60-80ºC can be generated by today's SHW systems. However, despite the temperature production indicated Tan, Zhang, Xu, Wang, Yu and Zhang (2012) found that other factors that were likely to restrict the photovoltaic energy generation include the status of solar radiation, of which is affected by the time of day, seasons and the visibility of clouds.

According to El Bassam, Maegaard and Schlichting (2013), the seasonal angles of the sun and cloud cover are associated with regional latitude have a negative impact towards photovoltaic panels. In addition, Hubbard (1989) states that extended cloud cover reduce the ability of photovoltaic systems to generate power at night because of the limited energy that was stored during the day which also impact sudden changes in power output.

Sass, Sass and Sass (2012) stated that during the course of the day and during the course of the year, sunlight light varies hence the amount of solar energy available to convert to usable power is influenced by a variety of

environmental factors. In addition, the dependence on variable sunshine hours makes solar its principle disadvantage including its short capacity utilisation. Thus, there is a need for additional components such as the need for energy storage and back-up system.

Despite the fact that South Africa has abundance of sunshine it does not always favour the photovoltaic technology. Solar panels actually perform better in cooler places because the only thing they respond to is photons. Photons perform better in cooler temperatures and cool zones like the European continent. The disadvantages of solar panels are that when the structure is used in an area which is very hot, the lifespan of the panel decreases. To use it in an area which is cool, its lifespan increases. It lasts longer in terms of durability and guaranteed performance.

Orientation of the structure

The output of the photovoltaic module or panel is affected by the exposure to the sunlight. Hence, the orientation of the roof or area where solar panels are retrofitted, location of the house, effect of shading such as the presence of trees as well as any other obstacles that could prevent exposure of the panels to the sun's rays.

Vandalism

Other disadvantages known to solar panels or modules are that retrofits that installed in lower grounds, they are left vulnerable to theft. Vandalism also proves to be problematic as stones can shutter the glass cover, hence the solar panels are unable absorb the efficient energy for peak performance.

Uncertainties

Nelson and Emmott (2013), indicates that the high capital cost of photovoltaic system creates a formidable barrier to implement photovoltaic system. In addition, the implementation costs required for investment capital in photovoltaic systems can only be recovered in a long period through savings in electricity bills. Moreover the authors stated that in order to determine the investment values, the implementation cost should be compared against energy benefits following the implementation of the photovoltaic technology. Bauner and Crago (2013) further notes that, regardless of the large upfront cost involved, investment in solar photovoltaic carries an uncertain future benefits.

The adoption of solar power system requires a considerable upfront investment cost. Keen (2015) cited in Bamford (2015) stated that prior to installing renewable energy, one needs to reduce their household electricity because solar electricity is expensive. According to Bauner and Crago (2013) because of the large upfront costs, adopting solar photovoltaic carry uncertain future benefits.

It is a technology that requires the end-user to pay for 15 years of electricity all at once. This makes it one of the economic challenges for solar technology adoption (European Photovoltaic Industry Association, 2015). In addition, Bauner and Crago (2013) discovered that because of changes in the price of photovoltaic, solar panel investment cost remains to be uncertain as well as energy savings and energy output of solar panels are mainly dependable on the price of electricity. Based on these discussions despites its benefits photovoltaic energy usage has numerous challenges. These challenges should be a catalyst for improvement in order for solar system to achieve its benefits.

Research Methodology

Marks and Yardley (2004) stated that the purpose of qualitative research is to gain an appreciation of how people's experiences are shaped by their subjective and socio-cultural perspective. That is; the different viewpoints of people in different circumstances; the ways that people actively make sense of their experiences; and the psychological, socio-cultural and linguistic factors and processes which influence the process of creating meaning. In order to achieve the research questions that guided this study a qualitative research was adopted. Furthermore, data was collected using semi-structured interview.

According to Walliman (2006), a semi-structured interview is implemented to encourage free expression from the respondents and to provide own insight and opinions. Moreover, with the questions already been predetermined the interview could take a different dimension as the researchers' aim is to obtain detailed information in the mist of the interview, but still resume to the main research question. As observed by Corbetta (2003) the interview process is not intended to create a general conversation between two people, but rather an interviewer-led procedure on which the interviewer seeks to lead the conversation strategically in order to receive the information required.

The target populations for the current study were the suburban households which had solar PVs and SWHs installation in Mondeor, Ridgeway, Winchester Hills and Suideroord. It was difficult to verify the number of residents who had installed solar PVs and SWH as no data currently exists. Therefore, the ideal target population for such a study was not feasible. Hence, according to Luborsky and Rubinstein (1995) a "rule of thumb" for the sample size is between 12 to 26 participants. Data collection took approximately three months (July to September 2015). The respondents of this study were purposively sampled using this non-probability sampling method. Hence, the sampling method adopted was to ensure that the appropriate respondents were invited to participate. The interviews took place during the weekends to accommodate the onerous schedule of the interviewees who accepted to

participate. The duration of the interviews lasted in the region of 20 to 30 minutes per respondent. In an effort to reach the potential participants, installers were contacted for assistance, unfortunately there assistance was not fruitful. Finally a total number of 15 individuals consented to participate in the semi-structured interviews.

The interviews were audio recorded and were transcribed verbatim in transcripts to ensure all data could be captured and analysed in order to identify emerging themes by applying Tesch's open coding approach. The data analysis procedure began by completing the transcription of the interviews by converting audio recording to transcribed text. The transcribed data was proof read and from that process themes emerged through typing out of primary data into a working document which enabled the researcher to go through the primary data thoroughly to allocate the relevant information through cutting and pasting therefore allocating the answers to the question in different categories relating to the research objectives.

Results and Discussions

Table 1 indicates the benefits the respondents encountered when they used photovoltaic energy. This answered objective one of the study i.e.

i. To determine the benefits of using solar power in South Africa households; and

Table 1: Positive experiences of solar energy adopters with the installation of solar water heater and solar photovoltaic panels

Category	**Themes**	**Sub-themes**
Benefits of solar	1. Savings	Less electric power Reduction in cost of electricity Water is always hot Payback period
	2. Hot water	Consistent hot water
	3. Lighting	Availability power during power cuts LED globes Security
	4. Shorter payback period	Installation of solar geysers

Theme 1: Savings

The findings revealed that one of their motivations to adopt the solar energy technology was the issue of the high increase in tariff rates of electricity in the country. Reddy (1995) affirms that, people become more motivated to install solar water heaters because of the high increases in electricity tariffs rates. Many participants revealed how happy there were seeing they were starting to reap the rewards of adopting solar energy technology by the reduction of electricity and saving money every month. Findings agree with previous work of Aigbavboa (2015) where findings in a survey ranked reduction in the cost of electricity in second place, as an impact of the solar water heater installation.

This brought in some relief on their spending months after the installation. According to one participant, he emphasised that he had accrued about 40% savings from his solar geyser. This particular finding did not concur with Veeraboina and Ratnam's (2012) work. They suggested that it could save an individual family 70% to 90% in electricity expenditure. Hence further researcher is advocated.

Theme 2: Consistency of hot water

All participants with a solar geyser installation in this study expressed how efficient the system was on its deliverance of hot water because the solar geyser had consistent hot water on clear skies. Findings thus agree with Aigbavboa's (2015) previous work where findings in a survey ranked having consistent hot water supply in first place as the highest impact of the solar geyser installation. Some participants expressed that at some point, the water was too hot and they ended up opening more cold water than the actual hot water. As a result they had to wait for a certain time for the water to cool off.

Theme 3: Lighting

Participants who installed the solar photovoltaic panels expressed the relief that they could have constant power to sustain the energy required in some or all electrical appliances in the household. Photovoltaic participants believed it was a huge saving compared to the conventional grid power supply because this meant that during load-shedding they could have lights, while others were in darkness. Another respondent indicated that solar photovoltaic adopters proved to be essential because power cuts meant that their security would be comprised as burglary could take place. As a result solar photovoltaic adopters, sourced a second backup of which were batteries. These findings were in agreement with the study by van der Spoel (2015) where batteries in a hybrid system automatically switched on and provide back-up power in the events of power cuts.

Interestingly, findings revealed that the temperature of the water inside the solar water heater (SWH) was astonishingly hot. Participants praised how the entire system was efficient on its deliverance of hot water. Individual recalled high levels of hot water in clear skies and high radiation and complained that taking immediate baths and showers could be difficult due to the extremely high temperature of the water. However the solar geyser cannot be ruled out by the fact that it is operating efficiently.

Theme 4: Shorter payback period

Another important factor in solar energy technology installation is the payback period which varies according to the cost and type of installation. The findings revealed how some participants, particularly the solar geysers adopters, where actually impressed on how quickly the system paid back. Some participants found the payback period as a benefit of installing these solar water heaters. Participants reported that the solar geysers paid itself back in 3 years by saving on the electricity bills regardless of the high initial cost. This particular finding did not concur with Batidzirai's *et al.*, (2009) findings. They found that for high-income households it took over 4 years for the solar water heaters to payback the initial cost of used in installation.

Table 2 indicates the challenges the respondents encountered when they used photovoltaic energy. This answered objective two of the study i.e.

ii. To determine the challenges faced by the South African households using the solar energy.

Table 2: Challenges of solar energy adopters with the installation of solar water heater and solar photovoltaic panels

Category	**Themes**	**Sub-themes**
Challenges of solar	1. Uncertainty	Consumption Leakage Insufficient solar panels to sustain batteries and feed load
	2. Water leakage	Materials and fittings
	3. Environmental conditions	Rain and cloud cover Charge ability of batteries
	4. Capital outlay	Upfront cost Payback period Additional cost
	5. Batteries	Charge

Theme 1: Uncertainty

The respondents were uncertain of the size of the solar panels to fully store enough energy that can sustain the batteries were in use. Furthermore, the maintenance of the solar system is a challenge when leakage is experienced in the system. This finding corroborate with the study of Eryilmaz and Homans (2013) they suggested that uncertainties about future prices and technology may dampen current investment even though investment in renewable resources would be wise if the current prices and technology were sure to persist into the future.

Theme 2: Water leakage

Depending on the quality of the solar geysers, participants revealed that the solar water heaters have issues in the long-run. Generally, leakage is known to be one of the popular challenges in geysers whether be electric or solar panels. Sometimes incorrect material replacements and trouble-free mechanical fittings affect the geysers negatively. One of the participants revealed that his downfall of the solar geyser was a simple fitting that led to a constant leakage of the solar geyser, evident from the running water coming down from the drain to the gutter.

It took the participant more than 2 years to actually notice the initial leakage, it was found to be a check-valve that turned out to be an incorrect fitting. The participant emphasised that the maintenance of the solar systems is carried out by the installer and the "call-out" fee is paid by the homeowner and contains a five year maintenance plan, depending on the type of the solar water heater. The second participant also indicated to have experienced leakage after purchasing the property and carrying routine checks at a later period. The findings from these two participants concurs with Aigbavbao's work (2015) where it was found that respondents complained of water leakage from the solar water heater installations, hence it was a challenge for the occupants'. Furthermore, findings with the work of Reddy (1995) revealed that the comparison of an electric water heater and a solar water heater installation cannot be compared on the issue of cost instead the expenses of maintaining its' over the same period of time makes a perfect valid comparison.

Theme 3: Environmental conditions

According to Chan, Qian and Lam, (2009), a very low efficiency of the system is experienced on a cloudy day which naturally occurs when there is insufficient solar radiation. It is clear from the findings that environmental conditions do play a vital roles in the performance of solar energy technology, either by hot water produced by solar water heaters or electrification of solar photovoltaic panels. Each individual dealt with the issue of rain and cloud cover differently, such that the performance of each of the type of solar energy

technology was different. These findings were similar and in agreement with the study of Tan *et al.,* (2011) who stated that the impact of the time of the day, seasons and visibility of the clouds restricts the application of solar photovoltaic energy generation.

Having assessed the performance of the solar photovoltaic panel adopters, the findings revealed by the participants suggested that they were not entirely left vulnerable without power because the energy input's ability was reduced to charge the batteries. The clouds' coverage, mostly in winter, actually influenced the solar photovoltaic panels and solar water heaters' low performance.

Solar geyser adopters also experienced the same environmental conditions impact as those who had installed the solar photovoltaic panels. But warm water came across as the most problematic factor. Solar geyser adopters shared their experiences and made it clear that the water was not warm and the conditions were neutral. In the case of solar water heaters the intelligence is built on the system. This means that the element automatically switched on when the temperature dropped and immediately switched over to Eskom. Veeraboina and Ratman (2012) affirms that, the system allows water to be preheated to increase the temperature of the water when the sunlight is low hence the solar water heater had a system already built-in.

Theme 4: Capital outlay

Investing in solar energy technology is known to be based on a long-term basis by saving electricity, with regards to bills. However, the size and type of solar energy technology is dependent on the complete cost system. Those who are energy conservative and yearn to be off-grid and minimise the dependence of grid electrification, acknowledge the cost of the investment. Participants revealed that the capital outlay of solar power was very expensive considering the fact that the upfront cost implementation was very high followed by a probable 10 years return on investment. These findings were in agreement with the study by Muhammad-Sukki *et al.,* (2012) where the shortest payback of solar photovoltaic was in the region of a 10 year period.

However, the findings were not similar to the study by Aman *et al.,* (2015) where less payback time was associated with the benefits of solar power. Also, Chow *et al.,* (2006) affirms that, compared to the electrical heating systems the solar water heaters had a high starting-cost which was a major barrier for the large-scale applications. This research finding also confirmed the fact that solar energy technology such as the solar photovoltaic technology seemed rather uninviting in the short term because it was deemed very expensive. These findings were in agreement with the study Nelson and Emmott (2013)

where the high capital cost of photovoltaic system created a barrier towards the implementation in the building.

Theme 5: Issue of batteries

The inability to recharge the batteries were some of the challenges faced by the participants' since the solar photovoltaic panel come with built in batteries and were installed in their properties. This impact means that the charging ability was reduced during overcast days which were lower opposed to peak performance during clear skies. The participants felt that the energy storage capacity did not last them as long as expected, which means that "they had to go back to the drawing board" and figure out the amount of energy they needed for the system to be efficient. This particular finding does not correspond with Raman, Murali, Sakthivadivel and Vigneswaran (2012) previous work where they found that the size of the PV batteries was equivalent to the energy stored inside and therefore should have the capacity to last one complete night.

The lack of capacity from the panels limits the energy's viability to deliver the required wattage and this means that the participants were losing solar power due to the fact that the battery charging did not last as long as it had to, in order to fulfil the optimum hours. Solar photovoltaic did not work without the presence of the sun and in some cases during the rainy weathers as stated by one of the two solar geyser and solar photovoltaic adopters. Thus additional components were installed to feed the house load and to meet all necessary energy requirements. The results were also in accordance with the study by Bauner and Crago (2013) where the dependence on the availability of sunshine hours together with its short utilisation required the end-user had to acquire additional energy supply and backup systems in place.

The sizes of the solar energy system batteries raised concerns and prove to be problematic when the system is activated. The participant stressed the size of the solar battery as equal to the size of a standard car and how quickly the batteries discharged to a low level. The BCA Research (2015) affirms that though lead batteries are cheaper they tend to have a short lifespan. Eventually it was found that the small-sized batteries were unable to charge properly when required to and eventually they had to be replaced by a bigger set of batteries. However, these findings were not in consensus with the study by Weniger, Tjaden and Quasching (2014) where he claimed that the small-sized batteries combined with photovoltaic systems guaranteed long-term economic benefits. This proves to be false as the findings display that the standard sized batteries were not efficient in the battery's lifespan. Therefore, a constant replacement will prove to be uneconomical

Conclusion

The main objective of this research was to find out what are the benefits of using solar photovoltaic and solar water heaters were, as well as the challenges facing the South African households in relation to the use of solar panels. The findings of the study and literature posits that despite all the uncertainties and expensive capital cost, solar power has demonstrated that its benefits are economical and significant to the end-user, in relation to electrification and water heating in the household. Most importantly, the end-user can invest the savings incurred from the cost of electricity and uninterrupted supply of hot water therefore minimising the dependence on national power utility.

The research findings should be interpreted with caution because the Gauteng Province and South Africa at the time of conducting this study were experiencing power cuts in the form of load-shedding. If load-shedding was not present, probably different response could have been suggested by the participants. Presently, the researcher would recommend the need to acquire much information about the solar product before implementing it. Thus intense research needs to be done to get the best from one's product.

Further research

In addition, a further study should be conducted to determine why many people are still relying on the national grid and why few people are using the solar photovoltaic system for electrification despite its economic benefits.

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