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Rural Households' Perceptions of the Adoption of Rooftop Solar Photovoltaics in Vhembe District, South Africa

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Abstract: Rooftop solar photovoltaics have the potential to successfully electrify rural and scattered communities worldwide. However, access to clean, high-quality, reliable and affordable energy remains elusive for several households in rural areas of the developing world. To fully comprehend, unpack and proffer meaningful solutions to this mismatch, energy sources in use and types in areas where rural electrification through solar home systems are profiled. Furthermore, grassroot communities' perceptions of rooftop solar photovoltaics (PVs) was explored. A case study design was adopted. Thirty (30) households were purposively sampled from three selected villages. Their perceptions on the adoption of solar photovoltaic home systems were analysed qualitatively using Atlas ti 8 software. Thematic network analysis was pursued. Households in the chosen villages use grid connections, paraffin, solar PV, firewood and candles to meet their energy needs. The chosen villages used energy for water heating, refrigeration, cooking, illumination, space heating, entertainment and ironing at the household level. In general, the participating households perceived solar PVs as a relatively cheap, easy-to-use, environmentally friendly alternative energy, and did not demand regular payments once installed. However, there was a discerning perception that solar was a weak technology that could not be relied on because it produces an inferior quality of energy, could be easily stolen and needed high capital investment beyond the reach of many consumers. The results obtained in this study highlight that the solar home system (SHS) rollout should be sensitive to rural communities' financial situations and be innovative in that low-income households are included. In addition, there is a need for a robust awareness programme that highlights the energy availability, reliability, quality, cost effectiveness and legal, health and safety benefits of the SHS to the rural families in the district.

Keywords: energy poverty; renewable energy; rooftop solar systems; perceptions

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1. Introduction

Energy poverty is a global challenge [1] that affects about 2.67 billion people who rely on traditional fuels [1–3] for cooking and heating. Most people lack access to clean and affordable energy sources in rural areas. They depend on traditional biomass [1]. Throughout the world, dependence on traditional biomass has exposed them to dangerous health hazards associated with air pollution [4,5]. To respond to this scourge, governments and other stakeholders have mounted efforts to transition rural and unelectrified communities from traditional biomass to the adoption of renewable energy resources that are much safer and cleaner [6]. However, the expensive cost of grid extension, unreliable infrastructure, lack of political will and institutional weakness [7] jeopardise these efforts. Moreover, the availability and affordability of renewable energy sources [8] have been a setback that frustrates energy transitioning. Despite all these setbacks, adopting renewable energy sources remains the only promising alternative for universal access to affordable and clean energy among the rural-poor communities in developing nations.

In South Africa, the government has committed to the socio-economic transformation of rural and marginalised communities through the provision of off-grid connections (solar home systems) [9]. In 1999, the Integrated National Electrification Programme (INEP) introduced a fee-for-service programme for 300,000 installations [9]. It was piloted in 2002 by Shell–ESKOM Joint Venture at the same time as the other six concessionaires [10]. The assumption was that a typical indigent home would require a 50 kWh for domestic services such as charging mobile phones, outdoor and indoor illumination, television, radio player and water heating. Consequently, the government has mandated a monthly supply of 50 kWh for low-income customers [9,11,12]. Overall, the programme targeted to generate 10,000 GWh by 2013 [13]. The programme missed its target [14], failing dismally [15]. The INEP initially targeted to electrify 300,000 households, but in 2012 only 46,000 were still using the systems [16]. This is a cause for concern. The programme's failure is attributed to the failure of the programme planners to factor in rural communities' views, attitudes and perceptions of the SHS. Despite the nobility of the programme, without consideration of the consumers' attitudes, the programme was bound to fail. Thus, this paper will unpack current energy sources, types and the rural communities' perceptions of using SHS as an alternative energy source in the rural communities of South Africa.

The adoption of rooftop solar home systems (SHSs) is one way for energy transitioning for rural and scattered communities of South Africa. Rooftop SHS is ideal in South Africa because the country's average solar radiation is 7 $KWh.m^2$ [17]. Cognisant of the challenges that compromised the INEP, solar radiation potential and energy poverty situation among the rural communities, the cabinet launched a New Household Electrification Strategy (NHES) [18]. The NHES sought to achieve universal energy access by 2025 by ensuring that only 90% of new houses will utilise the national grid. The remaining 10% will be electrified with high-quality off-grid SHS (i.e., 50 to 100 Wp stand-alone SHS recommended for off-grid electrification). This decision resulted from the realisation that rooftop solar photovoltaic systems are the most promising technology for practical rural electrification. Secondly, SHSs are proving to be a more resilient and efficient electricity system for the rural unelectrified communities [19]. Generally, there is a rapid transition from traditional centralised electricity generation and intensive use of fossils to isolated rooftop solar home systems [20]. Thus, the NHES was launched in 2013. As a result of these two crucial attempts to electrify rural villages with rooftop SHSs, rural communities in South Africa were exposed to the use of solar home systems. In an effort to understand the SHS adoption impediments, this paper profiles energy sources and types used in three selected villages in the Vhembe District (Duvhuledza, Mbahe and Tshamutilikwa) that participated in both the INEP and NHES programmes in the past. Finally, the rural households' perceptions of rooftop solar PV technology are explored.

2. Theoretical Background

(a) Energy Ladder Approach

Fuel use and choice among households are explored through the energy ladder model (ELA) [21]. The model assumes that a household's income will increase a family shifts to more modern and cleaner energy sources such as liquid petroleum gas (LPG) and electricity. In addition, the model assumes that energy consumption increases with more efficient fuels. Therefore, energy sources for most rural households are biomass, including fuelwood, charcoal and agricultural waste. According to this theory, homes move up the ladder, from biomass to paraffin and then LPG or electricity due to increased disposable income and improved lifestyles. Thus, technological advancements aimed at improving energy efficiency are only afforded and resorted to by households with disposable income. Central to the ELA is household income to move from one fuel to another in a linear trend. Many scholars have criticised this since households do not necessarily follow the energy ladder because of their financial position. Multiple fuel use approaches have debunked this approach. Due to these weaknesses of the energy ladder approach, ELA must be used alongside the multiple fuel approach.

(b) Multiple Fuel Use Approach

This approach responds directly to the shortcomings of the energy ladder approach. It postulates that poorest rural households, particularly in developing nations, do not move from one fuel to another; instead, they use multiple fuel sources found at all levels of the energy ladder. Different fuels are not switched, but fuel staking is pursued whereby fuels for cooking are added, and even the most traditional ones are not displaced or abandoned [22]. For instance, in Zimbabwe, access and availability have been identified as the driving forces for fuel choice [23]. As such, household fuel choice is not dependent on economic factors alone but on several factors that include gender, the level of education and household head [24]. Cultural and taste preferences contribute to household fuel choice [25]. Households act rationally; thus, they move up and down the ladder due to several factors which might be cultural. Understanding the factors that influence household fuel choices is essential before concentrating on shifts [26]. Thus, in this paper, a more holistic approach combining the insights of ELA and MFUA was applied to understand energy sources, types and rural communities' perceptions of renewable energy sources such as solar photovoltaics.

3. Materials and Methods

The current case study was conducted in Mbahe, Dhuvuledza and Tshamutilikwa which are in the Thulamela municipality of the Vhembe District in South Africa. The villages are found in the eastern part of the municipality towards the Kruger National Park (Figure 1). They are mainly rural with scattered households. Thirty (30) households, ten (10) per village, were selected via a case study design. Only those households that participated in the SHS Electrification Programme implemented by the Thulamela Local Municipality and Solar Vision Private Limited were purposively selected for the study. Before the actual data collection, SHS Electrification Programme beneficiaries were identified in each village. Out of the identified households, only ten were randomly selected per village. Creswell and Tashakkori (2007) contend that ten respondents constitute a large enough sample size for a phenomenological study in qualitative studies [27]. In contrast, Morse (1995) suggests that six respondents are sufficient to reach data saturation in a phenomenological study [28]. Furthermore, Bernard (2011) contends that the ideal standard for qualitative sample size is "to interview to redundancy" [29] or to interview to saturation [30]. Given the lack of consensus on the appropriate sample size in exploratory studies, this study targeted 30 respondents, far beyond the suggested sample size for explorative studies in the literature. In-depth face-to-face interviews were conducted to solicit individual households' insights on the rooftop solar home systems and the current energy uses, types and principal fuel sources. The responses were recorded using a voice recorder. In all instances where the local language (Venda) was used, it was translated into the English at transcribing stage. Transcribe data were exported to Atlast ti as a Hermeneutic Unit. It was analysed using Thematic Network Analysis (TNA) in Atlas ti version 8. The data were analysed using open coding, code by list and in vivo. The relationship and logical pattern explaining the perceived advantages and disadvantages of adopting an SHS were extracted from the data using the linking and related functions under Network View Manager.

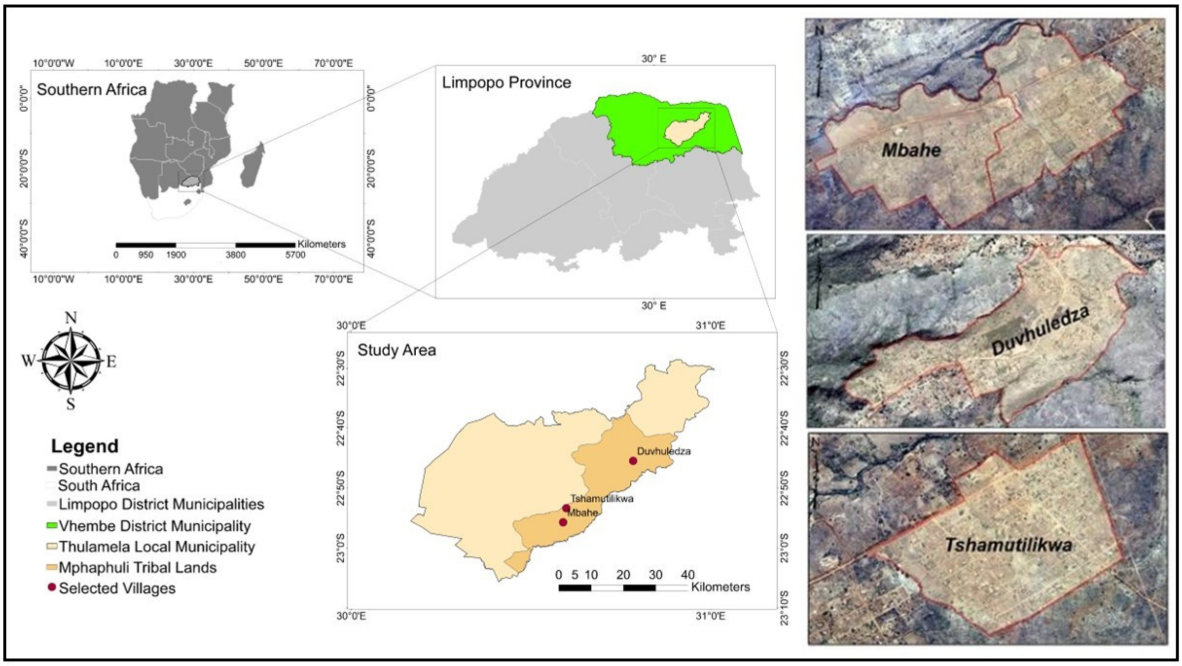

Figure 1. A map of the study site.

4. Results

4.1. Demography

Most of the study's thirty respondents (83%) were females. Almost 36% of females were residents of Tshamutilikwa. Adults aged between 36 and 60 comprised 60% of the total number of the respondents, with the elderly constituting about a third, 30% of the respondents. Youths within the 18- and 35-year-old range made up 10% of the respondents. As indicated in Table 1, in Tshamutilikwa, no youth was interviewed. Duvhuledza village had the highest number of youths (7%) participating in this study.

Table 1. Demographic characteristics of the respondents in the study on the perception of solar PV adoption.

		Mbahe	Duvhuledza	Tshamutilikwa	Total Frequency (n = 30)	Cumulative (%)
Gender	Male	2	2	1	5	16.7
	Female	8	8	9	25	83.3
Age	Youths (18–35 years)	1	2	0	3	10
	Adults (36–60 years)	6	7	5	18	60
	Elderly (61+ years)	3	1	5	9	30

4.2. Energy Types and Uses

The interviews revealed that families use various energy sources in the selected villages. The dominant prevalent energy sources in the chosen villages are grid electricity, paraffin, solar photovoltaics, firewood and candles. These sources meet household energy needs at the household level, ranging from cooking, water heating, indoor and outdoor illumination, refrigeration, ironing (straightening fabric), air conditioning, entertainment and space heating. Presented in Table 2 is how each energy source is used at the household level, as extracted by the interviews.

Table 2. Energy types and their uses in a household in the rural areas of the Vhembe District.

Domestic Energy Use	Energy Source(s)	Frequency (N = 30)	Cumulative Percentage (%)
1. Illumination	• Candles	3	10.0
	• Paraffin lamps	1	3.3
	• Battery cells	1	3.3
	• Solar photovoltaics	1	3.3
	• Grid electricity	22	73.3
	• Grid electricity	29	96.7
2. Water heating	• Solar geyser	1	3.3
	• Grid electricity	14	46.7
	• Liquefied petroleum gas	2	6.6
	• Firewood	21	70
3. Entertainment	• Battery cells	1	3.3
	• Grid electricity	28	93.3
4. Cooking	• Firewood	24	80.0
	• Electricity	17	56.7
	• Liquefied petroleum gas	2	6.6
5. Space heating	• Liquefied petroleum gas	1	3.3
	• Firewood	6	20
6. Air conditioning	• Nothing	16	53.3
	• Electricity	13	43.3
7. Ironing clothes	• Firewood	8	26.7

(a) Grid electricity

Households are using grid electricity for space heating, refrigeration, cooking, household lights, water heating, entertainment and air conditioning at the household level in the selected villages. As presented in Table 2, 29 and 28 out of 30 participants use grid electricity for refrigeration and entertainment. As shown in Table 2, 22 of the 30 that were interviewed use it for illumination compared to 17 for cooking. About half of the survey households used it for water heating and air conditioning. These findings align with Motjoadi, Bokoro and Onibonoje, who concluded that the primary purpose of electricity for rural dwellers is domestic use [31]. Many rural communities that are connected to the grid in sub-Saharan Africa are restricted to lighting, television, radio and cell phone charging [1,32]. They further posit that rural communities cannot buy electrical appliances. This view is echoed by [31], who argue that electricity affordability remains a challenge for rural communities despite being connected to the grid. Overall, grid connections in rural communities of developing countries are struggling with reliability, stability, sustainability, power quality and efficiency [33]

(b) Paraffin

As shown in Table 2, some households use paraffin as an energy source. It is mainly used for household lights. Earlier studies in South Africa have found a similar trend [34–36]. Interestingly, paraffin was only mentioned by one of the thirty households participating in this study. This is in line with the observation by [37], who observed that the reliance on paraffin for lights is not uniform across geographical areas and within individual communities. They said that only the poorest and vulnerable communities use paraffin with only limited access to other energy forms. According to the energy ladder hypothesis, the use of paraffin is one step from unclean sources such as biomass [38]. In other words, the use of paraffin for lights is a shift from low-quality fuels such as biomass to more convenient, versatile and cleaner modern sources [21]. Despite categorising the use of paraffin as an improvement on the energy ladder, it remains an unclean energy source that is detrimental to both human health and the environment. It is worth noting that a separate study in different villages of the Vhembe District revealed that paraffin is being used for cooking [39].

(c) Solar Photovoltaics

Solar photovoltaics systems are one of the energy sources that emerged in the study. As indicated in Table 2, it is exclusively used for water heating and indoor and outdoor illumination. It is apparent from Table 2, that only one participant in the study mentioned solar PV systems. This is in line with the findings of [32], who observed that the use of solar PV systems is very minimal in Southern Africa. In South Africa, solar PV systems are for lighting and home appliances in rural communities [40]. Surprisingly, the solar module price is declining steadily [40], but there is still low uptake of the technology among the rural communities of the Vhembe District. If properly harnessed, solar PV technology would be contributing to about 14% of the total energy supply in the country by 2050 [41]. In addition, an installation of a 50 kWh/m can save ZAR 100 billion per annum and save the struggling national grid by generating 9720 GWh [42], ultimately cutting carbon dioxide emissions of about 5.8 million metric tonnes.

(d) Firewood

The use of firewood among the rural households in the Vhembe District is predominantly for ironing clothes, water heating and space heating. Table 2 reveals that 8 out of the 30 homes who partook in this research mentioned using firewood for ironing clothes. The bulk (24) of the people among the participating families use firewood for cooking, while 21 used it for water heating. Only six used it to meet their space heating needs. These findings align with the studies by [32,39], which noted that some rural and remote communities rely on burning fuelwood for cooking and heating. The South African Energy Outlook of 2019 has predicted that about 10% of the South African population will still be using fuelwood for cooking by 2030 [43]. They observed that many families in sub-Saharan Africa still use dirty fuels such as firewood for light and cooking. About 730 million rely on biomass such as firewood in sub-Saharan Africa [44]. Notably, most families in rural South Africa are not employed and do not have a stable source of income [39]. Firewood is prevalent among the poor [45,46] because they can afford this source financially.

It is worth noting that households relying on firewood spend a considerable amount of time and labour gathering from near and afar [1]. Let alone the severe threat it poses to the environment and human health [47]. At the receiving end of these activities are children and women. The results conform with the findings of Statistics South Africa, which observed that about 40% of the rural dwellers in the Limpopo Province use firewood for cooking [48]. Currently, meeting energy needs using firewood is cheaper than using any other available energy source [39]. This explains why despite almost 100% grid connection in some villages of the district and incentives for using it such as offering accessible promotional units by the service provider, families still opt for fuelwood use as the energy of choice for their cooking and water heating needs. High fuelwood usage for cooking is driven by the belief that food cooked with firewood tastes better than that cooked with electricity [39]. Household energy preferences are multifaceted and dynamic. Thus, an attempt to promote new energy technology needs thorough socio-economic, cultural and taste research.

(e) Candles

Some households were using candles for lighting purposes. Notably, as Figure 1 shows, candle usage was not that popular. Representatives of only two households were of this view. This is consistent with Rahut, Behera and Ali's findings that only 2.9% of Eastern and Southern African households used candles for illumination [32]. This finding shows that rural communities still rely on unclean energy sources to meet their household illumination needs. Reliance on candles for lighting exposes rural families to both health and physical hazards.

4.3. Rural Communities' Perceptions of Solar Home Systems

Several rural communities' perceptions of the adoption and use of SHS among rural households in South Africa emerged and are presented in Table 3. Firstly, 23% of the rural households thought solar systems were unaffected by load shedding. As shown in Table 1, this view was shared across the villages. According to Piliso, Senzanje and Dhavu, since 2010, the South African electrical power distribution company ESKOM has struggled to provide enough electricity for the country [49]. As a result, load shedding has become perennial in the country. The prevalence and devastating effect of load shedding have been confirmed by Mabunda, who concluded that it has many stages [50]. Once effected, electricity-powered gadgets and devices switch off for hours. The households are restricted from doing or enjoying tasks and services that need electrical power. As a result, this has subjected the populace to continued bouts of load shedding. Thus, in the context of recurrent and intensifying load shedding, rural communities feel solar photovoltaic adoption has the potential to spare them from devasting effects of load shedding.

Table 3. Rural households' perceptions of solar home systems (SHSs).

Perceived Advantages of a SHS	Village Distribution	Frequency (n = 30)	Cumulative (%)	Perceived Disadvantages of Adopting a SHS	Village Distribution	Frequency (n = 30)	Cumulative (%)
A solar home system is not affected by load shedding	Duvhuledza (2) Mbahe (4) Tshamutilikwa (1)	7	23.0	A SHS does not work well during cloudy or rainy climatic conditions	Duvhuledza (4) Mbahe (7) Tshamutilikwa (6)	17	56.7
Solar technology is relatively cheap (Installation and maintenance)	Duvhuledza (3) Mbahe (4)	7	23.0	Solar equipment is expensive	Duvhuledza (1) Mbahe (11)	2	6.7
Solar technology is simple and easy to use	Duvhuledza (2)	2	6.7	Solar PV panels can be stolen easily	Duvhuledza (2) Mbahe (1) Tshamutilikwa (1)	4	13.3
The energy is derived from a renewable resource, the sun, and is environmentally friendly	Duvhuledza (1) Mbahe (1) Tshamutilikwa (2)	4	13.3	A SHS's efficiency is reduced by the presence of dust particles which are prevalent in the rural villages	Tshamutilikwa (1)	1	3.3
Once installed, the SHS does not require regular payments	Mbahe (1) Tshamutilikwa (1)	2	6.7	Solar technology produces inferior quality energy, which can power limited household appliances	Duvhuledza (2) Tshamutilikwa (1)	3	10
Solar home system adoption reduces energy supply demand on-grid connections	Tshamutshezi (1)	1	3.3				

It also emerged that 23% of the rural communities perceive solar adoption as cheap, i.e., installation and maintenance. This perception mainly came from participants from Mbahe village. Indeed, SHS installation and maintenance are relatively cheap. In Bangladesh, Momotaz and Karim posit that rural communities share the same sentiment, with over 76% indicating that the SHS cost was within the purchasing ability [51]. In Pakistan, a similar trend among rural and scattered communities was observed, where SHS was considered an affordable technology for rural and scattered communities [52]. Notably, this could be a result of the general solar financing system. According to Ngoepe et al., the pay-as-you-go billing system has demonstrated that off-grid providers go beyond promoting and providing clean and sustainable rural electrification but providing affordable financial services for profit-making [53]. Notably, about 6.7% of the participating families felt that installation and maintenance are too expensive and beyond their reach. This sentiment mainly came from Mbahe and Duvhuledza villages. In other words, the affordability of SHS is contested among rural families. Thus, as much as installation and maintenance are generally cheap, this divided perception could explain why its uptake is not encouraging in the district, as the majority are not using it.

In addition, 6.7% of rural families participating in this study believe that SHS has the propensity to help them save household financial resources. Noticeably, this view is harboured in Duvhuledza and Mbahe. This observation is in sync with the findings of [54], which concluded that SHS is a low-cost solution to rural electrification if adopted and has the potential to help in energy spending. To further bolster this perception, [55,56] have observed that the price for SHS modules has become increasingly attractive. This same sentiment is echoed by [57,58], who noted that the prices of SHS modules have drastically dropped. According to the World Bank, using SHS reduces a household's cost of lights and vulnerability to domestic health and safety hazards [3]. The SHS has become financially attractive due to heavy government subsidies [56,58].

Results have also revealed that 6.7% of the families in the selected villages perceive SHS as a simple and accessible technology. This view only emerged from Duvhuledza village. This sentiment was shared by [59] when they concluded that SHS is touted for technical quality in Bangladesh. This perception is also seen in Vietnam and Sweden [60,61]. Moreso, SHS is perceived as environmentally friendly. This is widely shared across all the participating villages. This is in sync with Missourian and Kopacek's findings which concluded that SHS is one of the environmentally friendly technologies [62]. It has also emerged that SHS, once installed, does not need regular payments. This gives this technology a comparative advantage over other technologies in the district; mainly, electricity is widely used, but people are not affording it now. Finally, the rural households believe that adopting SHS helps ease the energy supply demand from the currently overwhelmed grid connection.

As much as the rural communities in the selected villages of the Vhembe District in South Africa had positive perceptions about the technology, it needs to be highlighted that some households have negative perceptions. For instance, the majority, i.e., 56.7% of the families, believe that SHS does not work well during cloudy and rainy climatic conditions. This finding conforms with the conclusions of [63], which conclude that indigent people targeted by off-grid entrepreneurs have trust issues with the technology. In Kenya, the SHS end-users also have trust issues; however, according to Faris, the M-Kope uses local pastors to create awareness and a market for SHS [64]. Thus, all these trust issues must be dealt with for rural electrification through SHS to succeed.

Some households believe that SHS photovoltaic cells can be easily stolen. About 13% of the families participating in this study shared this view. As indicated in Table 3, two households were from Duvhuledza, each from Mbahe and Tshamutilikwa. One of the unintended results was that the participating families showed that SHS's efficiency is reduced by the accumulation of dust on the panels. A possible explanation for this result is that most of the roads in rural areas of Vhembe District are not tarred. Interestingly, system reduction due to the accumulation of dust particles was only mentioned in Tshamutilikwa, with about 3.3% of the families participating in this study. Finally, it also emerged that rural families in the Vhembe District felt that SHS does not produce adequate quality energy.

About a tenth of the respondents raised the fact that the household solar system is limited in terms of its capacity to power. They argued that an SHS could not be used to cook or iron clothes. This conforms to Taylor and So's findings, which note that solar power generation is far lower than the grid supply [65]. This reinforces the results obtained in an earlier study [20]. The latter scholars concluded that a SHS could not constantly supply power because its sources varied from one season and geographical location to another.

5. Conclusions

Even though the participating families indicated positive perceptions of solar photovoltaic technology, its proliferation in rural areas is hindered by high capital and maintenance costs. In addition, the results reveal that families in the rural communities of South Africa are still reliant on unhealthy fuels such as wood, paraffin and candles. This situation is compounded by the fact that, in Africa, more than two-fifths of the population live under USD 1.90 a day; such people are not considered for basic financial services such as insurance, bank loans and others as they do not have a steady income, own a personal bank account and reliable credit history. Thus, SHS providers should not only leverage the financial implications of using unclean energy sources such as fossil fuels and biomass but also the financial capabilities of the end-users of the technology. Thus, Roberts suggests that solar home systems innovators need tailor-made service charges in line with the financial situation of the communities they intend to electrify.

Concisely, South African rural communities have the potential to adopt renewable energy sources, but they are not adequately harnessed. Currently, the government is subsidising more on-grid connections at the expense of off-grid connections. Central to this is the politicisation of rural electrification in South Africa. Areas earmarked for SHS encroached with grid electricity to score cheap electoral votes. Therefore, political and trade unions' interference exacerbates rural electrification challenges through SHS in South Africa. In addition, the SHS implementation programme needs to be aware of the capacity and system types. Besides the system capacity, SHS should be evaluated to improve rural communities' energy access regarding availability, reliability, quality, cost effectiveness, legal, health and safety. All this information needs should be shared with rural families who intend or who are willing to adopt an SHS. It will help decrease the prejudices harboured by the rural communities.

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Informed Consent Statement: All the research participants voluntary participated in this study. All their rights were expressed and explained clearly both in writing and verbally.

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References

1. Muhumuza, R.; Zacharopoulos, A.; Mondol, J.D.; Smyth, M.; Pugsley, A. Energy consumption levels and technical approaches for supporting development of alternative energy technologies for rural sectors of developing countries. *Renew. Sustain. Energy Rev.* **2018**, *97*, 90–102. [CrossRef]
2. International Energy Agency. World Energy Outlook (WEO): Energy Access Database. 2016. Available online: https://www.iea.org/reports/world-energy-outlook-2016 (accessed on 23 May 2022).
3. World Bank. World Development Indicators. 2017. Available online: http://hdl.handle.net/10986/26447 (accessed on 3 May 2022).
4. Chafe, Z.A.; Brauer, M.; Klimont, Z.; Van Dingenen, R.; Mehta, S.; Rao, S.; Riahi, K.; Dentener, F.; Smith, K.R. Household cooking with solid fuels contributes to ambient PM2. 5 air pollution and the burden of disease. *Environ. Health Perspect.* **2014**, *122*, 1314–1320. [CrossRef]
5. Muller, C.; Yan, H. Household fuel use in developing countries: Review of theory and evidence. *Energy Econ.* **2018**, *70*, 429–439. [CrossRef]
6. Mensah, J.T.; Adu, G. An empirical analysis of household energy choice in Ghana. *Renew. Sustain. Energy Rev.* **2015**, *51*, 1402–1411. [CrossRef]
7. Yao, C.; Chen, C.; Li, M. Analysis of rural residential energy consumption and corresponding carbon emissions in China. *Energy Policy* **2012**, *41*, 445–450. [CrossRef]
8. Momodu, I.M. Domestic energy needs and natural resources conservation: The case of fuelwood consumption in Nigeria. *Mediterr. J. Soc. Sci.* **2013**, *4*, 147. [CrossRef]
9. Meyer, L.E.; Overen, O.K. Towards a sustainable rural electrification scheme in South Africa: Analysis of the Status quo. *Energy Rep.* **2021**, *7*, 4273–4287. [CrossRef]

10. Borchers, M.; Qas, N.; Guant, T.; Mavhungu, J.; Winkler, H.; Afrane-Okese, Y.; Thom, C. National Electrification Programme Evaluations: Summary Report. 2001. Available online: https://open.uct.ac.za/bitstream/handle/11427/22682/Borchers_2001.pdf?sequence=6 (accessed on 10 March 2022).
11. Kambule, N.; Yessoufou, K.; Nwulu, N.; Mbohwa, C. Exploring the driving factors of prepaid electricity meter rejection in the largest township of South Africa. *Energy Policy* **2019**, *124*, 199–205. [CrossRef]
12. Kelvin, O.O.; Edson, M.L.; Golden, M. Thermal, economic and environmental analysis of a low-cost house in Alice, South Africa. *Sustainability* **2017**, *9*, 425. [CrossRef]
13. Department of Minerals and Energy. 2003. Available online: https://www.gov.za/nso/documents/department-minerals-and-energy-annual-report-20022003 (accessed on 10 March 2022).
14. Thopil, M.S.; Bansal, R.C.; Zhang, L.; Sharma, G. A review of grid connected distributed generation using renewable energy sources in South Africa. *Energy Strategy Rev.* **2018**, *21*, 88–97. [CrossRef]
15. World Bank. Detailed Case Study: The South African Solar Home System (SHS) Concessions, Evaluation of Rural Electrification Concessions in Sub-Saharan Africa. Available online: http://documents.worldbank.org/curated/en/708211498162775424/pdf/116659-WP-PUBLIC-P150241-37p-Detailed-Case-Study-South-Africa.pdf (accessed on 10 April 2022).
16. Conway, D.; Robinson, B.; Mudimu, P.; Chitekwe, T.; Koranteng, K.; Swilling, M. Exploring hybrid models for universal access to basic solar energy services in informal settlements: Case studies from South Africa and Zimbabwe. *Energy Res. Soc. Sci.* **2019**, *56*, 101202. [CrossRef]
17. Eberhard, A.; Kolker, J.; Leigland, J. *South Africa's Renewable Energy IPP Procurement Program: Success Factors and lLessons*; World Bank Group 1202; World Bank: Washington, DC, USA, 2014; Available online: https://openknowledge.worldbank.org/handle/10986/20039 (accessed on 13 May 2022).
18. Department of Minerals and Energy. 2015. Available online: https://www.platinumiris.co.za/wp-content/uploads/doe/01/2015%20-%202016%20Department%20of%20Energy%20Annual%20Report.pdf (accessed on 12 June 2022).
19. Barrie, J.; Cruickshank, H.J. Shedding light on the last mile: A study on the diffusion of Pay as You Go Solar Home Systems in Central East Africa. *Energy Policy* **2017**, *107*, 425–436. [CrossRef]
20. Akikur, R.K.; Saidur, R.; Ping, H.W.; Ullah, K.R. Comparative study of stand-alone and hybrid solar energy systems suitable for off-grid rural electrification: A review. *Renew. Sustain. Energy Rev.* **2013**, *27*, 738–752. [CrossRef]
21. Van der Kroon, B.; Brouwer, R.; Van Beukering, P.J. The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renew. Sustain. Energy Rev.* **2013**, *20*, 504–513. [CrossRef]
22. Hoffman, H.; Uckert, G.; Reif, C.; Muller, K.; Sieber, S. Traditional biomass energy consumption and the potential introduction of firewood efficient stoves: Insight from western Tanzania. *Reg. Environ. Chang.* **2015**, *15*, 1191–1201. [CrossRef]
23. Campbell, B.M.; Vermeulen, S.J.; Mangono, J.J.; Mabugu, R. The energy transition in action: Urban domestic fuel choices in changing Zimbabwe. *Energy Policy* **2003**, *31*, 553–562. [CrossRef]
24. Uhunamure, S.E.; Nethengwe, N.S.; Tinarwo, D. Correlating the factors influencing household decisions on adoption and utilisation of biogas technology in South Africa. *Renew. Sustain. Energy Rev.* **2019**, *107*, 264–273. [CrossRef]
25. Arthur, M.; Bond, C.A.; Willson, B. Estimation of elasticities for domestic energy demand in Mozambique. *Energy Econ.* **2012**, *34*, 398–409. [CrossRef]
26. Zaku, S.G.; Abdallah, A.; Olayande, J.S.; Kabir, A.; Tukur, A. Comparative studies of household energy use in Nigeria: A case of Gwagwalada and Gwako in Gwagwalada Area Council of Abuja FCT. *Swift J. Econ. Int. Financ.* **2015**, *1*, 5–9.
27. Creswell, J.W.; Tashakkori, A. Differing perspectives on mixed methods research. *J. Mix. Methods Res.* **2007**, *1*, 303–308. [CrossRef]
28. Morse, J.M. The significance of saturation. *Qual. Health Res.* **1995**, *5*, 147–149. [CrossRef]
29. Bernard, H.R. *Research Methods in Anthropology: Qualitative and Quantitative Approaches*, 5th ed.; Rowman Altamira: New York, NY, USA, 2011.
30. LeCompte, M.D.; Schensul, J.J. *Designing and Conducting Ethnographic Research: An Introduction*; Rowman Altamira: New York, NY, USA, 2010; Volume 1.
31. Motjoadi, V.; Bokoro, P.N.; Onibonoje, M.O. A review of microgrid-based approach to rural electrification in South Africa: Architecture and policy framework. *Energies* **2020**, *13*, 2193. [CrossRef]
32. Rahut, D.; Behera, B.; Ali, A. Factors determining household use of clean and renewable energy sources for lighting in Sub-Saharan Africa. *Renew. Sustain. Energy Rev.* **2017**, *72*, 661–672. [CrossRef]
33. Ahlborg, H.; Hammar, L. Drivers and barriers to rural electrification in Tanzania and Mozambique Grid-extension, off-grid, and renewable energy technologies. *Renew. Energy* **2014**, *61*, 117–124. [CrossRef]
34. Griffin, N.J.; Banks, D.I.; Mavrandonis, J.; Shackleton, C.M.; Shackleton, S.E. *Household Energy and Wood Use in a Peripheral Rural Area of the Eastern Transvaal Lowveld*; Department of Mineral and Energy Affairs: Pretoria, South Africa, 1992.
35. Davis, M. Rural household energy consumption: The effects of access to electricity—Evidence from South Africa. *Energy Policy* **1998**, *26*, 207–217. [CrossRef]
36. Howells, M.I.; Alfstad, T.; Victor, D.G.; Goldstein, G.; Remme, U. A model of household energy services in a low-income rural African village. *Energy Policy* **2005**, *33*, 1833–1851. [CrossRef]
37. Madubansi, M.; Shackleton, C.M. Changing energy profiles and consumption patterns following electrification in five rural villages, South Africa. *Energy Policy* **2006**, *34*, 4081–4092. [CrossRef]
38. Sepp, S. *Multiple Household Fuel Use: A Balanced Choice between Firewood, Charcoal and LPG*; GIZ: Frankfurt, Germany, 2014.

39. Uhunamure, S.E.; Nethengwe, N.S.; Musyoki, A. Driving forces for fuelwood use in households in the Thulamela Municipality, South Africa. *J. Energy S. Afr.* **2017**, *28*, 25–34. [CrossRef]
40. Aliyu, A.K.; Modu, B.; Tan, C.W. A review of renewable energy development in Africa: A focus in South Africa, Egypt and Nigeria. *Renew. Sustain. Energy Rev.* **2018**, *81*, 2502–2518. [CrossRef]
41. Banks, D.; Schäffler, J. The Potential Contribution of Renewable Energy in South Africa. Johannesburg, South Africa: Sustainable Energy & Climate Change Project (SECCP). 2006. Available online: https://www.ee.co.za/wp-content/uploads/legacy/Gener%201.pdf (accessed on 13 April 2022).
42. Ab Kadir, M.Z.A.; Rafeeu, Y.; Adam, N.M. Prospective scenarios for the full solar energy development in Malaysia. *Renew. Sustain. Energy Rev.* **2010**, *14*, 3023–3031. [CrossRef]
43. South African Energy Outlook. 2019. Available online: https://www.iea.org/reports/africa-energy-outlook-2019 (accessed on 3 March 2022).
44. International Energy Agency. 2014. Available online: https://www.iea.org/reports/world-energy-outlook-2014 (accessed on 3 March 2022).
45. Das, S.; De Groote, H.; Behera, B. Determinants of household energy use in Bhutan. *Energy* **2014**, *69*, 661–672.
46. Behera, B.; Jeetendra, A.; Ali, A. Household collection and use of biomass energy sources in South Asia. *Energy* **2015**, *85*, 468–480. [CrossRef]
47. Mishra, V. Indoor air pollution from biomass combustion and acute respiratory illness in preschool age children in Zimbabwe. *Int. J. Epidemiol.* **2003**, *32*, 847–853. [CrossRef]
48. Statistics South Africa. General Household Survey 2014. Report Number P0318. Available online: http://www.statssa.gov.za/publications/P0318/P03182014.pdf (accessed on 10 April 2022).
49. Piliso, P.; Senzanje, A.; Dhavu, K. The extent, characteristics and potential of solar powered irrigation systems in South Africa. *J. Energy S. Afr.* **2021**, *32*, 26–40. [CrossRef]
50. Mabunda, N.E. Use of Photovoltaic Energy to Minimise the Impact of Load-shedding in South Africa. In Proceedings of the 2021 International Conference on Electrical 2021, Computer and Energy Technologies (ICECET), Cape Town, South Africa, 9–10 December 2021; IEEE: Piscataway, NJ, USA, 2021; pp. 1–4.
51. Momotaz, S.N.; Karim, A.M. Customer satisfaction of the solar home system service in Bangladesh. *World* **2012**, *2*, 193–210.
52. Omara, Z.M.; Kabeel, A.E.; Abdullah, A.S. A review of solar still performance with reflectors. *Renew. Sustain. Energy Rev.* **2017**, *68*, 638–649. [CrossRef]
53. Ngoepe, T.; Henriksen, T.F.; Power, A.P.; Panulo, B.; Modungwa, B.; Scholtz, L.; Gulati, M. Switching on Finance for Off-Grid Energy. Bertha Centre, WWF-SA. 2016. Available online: https://gsbberthacentre.uct.ac.za/researching/switching-on-finance-for-off-grid-energy/ (accessed on 10 April 2022).
54. IEA. *Energy Access Outlook 2017: From Poverty to Prosperity*; International Energy Agency: Paris, France, 2017. [CrossRef]
55. Mitscher, M.; Rüther, R. Economic performance and policies for grid-connected residential solar photovoltaic systems in Brazil. *Energy Policy* **2012**, *49*, 688–694. [CrossRef]
56. Urmee, T.; Harries, D. Determinants of the success and sustainability of Bangladesh's SHS program. *Renew. Energy* **2011**, *36*, 2822–2830. [CrossRef]
57. Azimoh, C.L.; Klintenberg, P.; Wallin, F.; Karlsson, B. Illuminated but not electrified: An assessment of the impact of Solar Home System on rural households in South Africa. *Appl. Energy* **2015**, *155*, 354–364. [CrossRef]
58. Waleedm, A.; Javed, M.R.; Riaz, M.T.; Virk, U.S.; Khan, S.; Mujtaba, A.; Ahmas, S.; Arshad, G. Study on Hybrid Wind-Solar System for Energy Saving Analysis in Energy Sector. In Proceedings of the 2020 3rd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), Sukkur, Pakistan, 29–30 January 2020; pp. 1–6. [CrossRef]
59. Qureshi, T.M.; Ullah, K.; Arentsen, M.J. Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan. *Renew. Sustain. Energy Rev.* **2017**, *78*, 754–763. [CrossRef]
60. Do, T.N.; Burke, P.J.; Baldwin, K.G.; Nguyen, C.T. Underlying drivers and barriers for solar photovoltaics diffusion: The case of Vietnam. *Energy Policy* **2020**, *144*, 111561. [CrossRef]
61. Palm, A. Local factors driving the diffusion of solar photovoltaics in Sweden: A case study of five municipalities in an early market. *Energy Res. Soc. Sci.* **2016**, *14*, 1–12. [CrossRef]
62. Masoumian, M.; Kopacek, P. End-of-life management of photovoltaic modules. *IFAC-PapersOnLine* **2015**, *48*, 162–167. [CrossRef]
63. Rastogi, C. M-Kopa solar: Lighting up the dark continent. *South Asian J. Bus. Manag. Cases* **2018**, *7*, 93–103. [CrossRef]
64. Faris, S.; Bloomberg. The Solar Company Making a Profit on Poor Africans. pp. 1–4. 2015. Available online: www.bloomberg.com/features/2015-mkopa-solar-in-africa/ (accessed on 1 April 2022).
65. Taylor, M.; So, E.Y. *Solar PV in Africa: Costs and Markets*; IRENA: Bonn, Germany, 2016.