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Speedy Adoption of Solar Home Systems in Sub-Saharan Africa

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Abstract – *Despite the strong commitment of various countries around the world towards energizing the unserved population in their communities, around 1.3 billion people still lack access to affordable and reliable electricity. Interestingly, technological advancement is gradually reducing the cost of investing in off-grid renewable energy solutions. Developing an appropriate business model can play a vibrant role in electrifying off-grid rural communities. Literature on various business models for rural electrification has revealed that the model for off-grid rural areas in emerging nations should be service-based, scalable to several use case scenarios, and permit transparentness and superiority of service. This paper intends to present the business model for the speedy adoption of solar home systems in sub-Saharan Africa. The work further looks into the existing business models in rural electrification. It suggests insights for stakeholders to subscribe to the scalable-pay-as-you-go (SPAYG) business model in the SSA countries in their bids to fast-track the deployment and adoption of green electricity to rural households and businesses. It was established based on the survey that the adoption of upgrades by various PAYG SHS companies in their business model will further accelerate the speedy of electrification access via PAYG SHS.*

Keywords: *Solar Photovoltaic, Electrification, Grid, Business Model, Technological Advancement, Rural Areas, Pay-as-You-Go, Off-grid.*

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I. Introduction

The latest reports issued by the United Nations (UN) offer recommendations on how energy poverty can be tackled globally and how to ensure that everyone in the world has access to affordable electricity by 2030 [1]. Energy access policies are becoming successful, with 2019 data revealing significant headway with a decrease in the total number of households without electricity from almost 860 million in 2018 to 770 million in 2019 (IEA, 2021). Likewise, encouraging policies have been applied in several countries in Africa that favor an increase in the electricity access rate. However, past progress in the electrification rate is being inverted as a result of the Covid-19 pandemic [3]. The condition is tough since most of the population without access to affordable electricity resides in the difficult terrain of developing countries' rural areas where the grid's extension is an impracticable substitute, and likewise, green technologies require significant capital. Thus, a monetary crisis such as constrained access to finance, unstable exchange, and interest rates are extensively decelerating the success of the worldwide electrification goals. Furthermore, some policies are connected to an unfruitful control of the energy sector, hence, the aim ought to move near decreasing access obstacles for the stakeholders in the energy industries [4].

Out of available off-grid renewable technologies, solar energy has the potential to be considered in large-scale commercial facilities, in addition to meeting the household's electricity needs [5]. Its enhanced efficiency, falling price, and helpful policy regime have made solar energy one of the chief forms of renewable energy globally [6-7]. Modern tactics for the speedy electrification of isolated areas should be

considered by developing favorable and affordable business models (BM) where the market is largely constrained. Electricity access can be defined as the percentage of the population in a particular area with effective access to electricity in comparison to the overall population. Likewise, the International Energy Agency (IEA) defined energy access as a "golden thread" that interweaves financial growth, human development, and environmental stability [8]. However, access to energy alone may not assure growth and development when market resources are inadequate. This shows that good business models are essential requirements. A business model can be defined as an inclusive scheme through which the project works plus the selection of technology, the financial capability of the model, the established setup, the obligation of numerous participants, and the regulatory and policy structure.

The conception of the business model has received better attention in the literature exploring ways to fast-track a transition to more sustainable energy systems [9]. However, business models may not drive major system changes except if they are braced by reforms in regulatory and market structures [10]. Little work has been reported in the literature on developing a business model for the rapid deployment of solar PV for rural and urban electrification. [11] presented a business model for enhanced solar photovoltaic (PV) adoption, emphasizing that a company's capability to plan and deliver value offerings that match customers' requirements is absolutely necessary in encouraging the use of solar PV technology. [12] mapped and examined the business models of 241 solar companies in Sweden using a scheme developed by Richardson (2008) coupled with the roles, events, and applications as stressed in solar business model literature. [13] presented a model to evaluate the success of solar home systems. [14] investigated the adoption of pay-as-you-go Solar home systems in Central East Africa. Importantly, Stojanovski et al., [15], reported that there is insufficient data on the connections between solar home systemproducts and the actual usage patterns by the customers as against presumed specified patterns by solar home system manufacturers. It was also discovered that the majority of the solar home systemusers were not using the system to power radios, TVs, or flashlights. The adoption of solar home systems for commercial activities was not studied.

However, no attention has been paid to how a customer can conveniently upgrade its current solar solution package either before or after completion of the payment for the solar package by the solar PV companies offering a pay-as-you-go (PAYG) business model. This work aims to fill this knowledge gap by responding to the research request: "How can solar PV companies offering PAYG include upgrading of solar package into their business model?" A business model named scalable-pay–as-you-go (SPAYG), with the primary target of allowing customers to upgrade their solar solution package, is proposed. The target is to facilitate access to affordable and sustainable electricity (via partnerships with telecommunication companies and the government) to rural off-grid households.

Also, we contribute to knowledge by drawing from twenty semi-structured interviews with customers of various Solar companies offering the PAYG model in Nigeria to demonstrate the usefulness of the proposed model. The insights gained from the conducted investigation can assist solar PAYG companies to retain their customers, communicate their proposals to customers, create value for customers and themselves, and boost their readiness to pay for the services provided. The objective of this work's novelty is to facilitate access to affordable and sustainable electricity for rural off-grid households through partnerships with telecommunication companies and the government. The novelty itself lies in the proposed Scalable Pay-As-You-Go (SPAYG) business model, which aims for the rapid adoption of solar home systems in Sub-Saharan Africa (SSA) by enabling customers to conveniently upgrade their solar solution packages either before or after completing payments. The study validates this model's usefulness through semi-structured interviews with customers of various PAYG solar companies in Nigeria.

II. Status of electrification existing in SSA

The proportional growth of access to electricity over the past two eras in SSA is very low (below 15%). According to the current overall installed capacity per capita of around 0.084 kW, which is approximately equal to 2.8%, 7%, and 21% of that of the USA, China, and India, respectively [16]. The proportion of the population that lacks access to electrical energy in SSA is around 56% which indicates that the rate of electrification in this region is not in balance with the populace growing rate and this number may rise to around 1.3 billion by 2050 [4], [7]. The map of Africa showing the countries in the SSA region is presented in Figure 1. The overall installed capacity in the SSA is 100 GW, which is considered to be lower compared to other world regions. The comparison of the installed capacity in SSA with other regions per million people is illustrated in Figure 2. From the Figure,

it is evident that the SSA with the installed capacity of 98 MW is incomparable to that of South Asia of 203 MW, Latin America and Caribbean (LAC) of 604 MW, and 803 MW for Middle East and North Africa (MENA). As mentioned previously, the bulk of the people that lack access to electricity in SSA resides in rural areas, where the purchasing power is usually limited and the mean daily income is usually around $2 per capita. With this low income, the majority of the rural dwellers might not be able to afford the expensive cost of connection to the electrical grid, which usually costs between $400 - 500 per sole connection for short distant locations and above $500 for long distances [4].

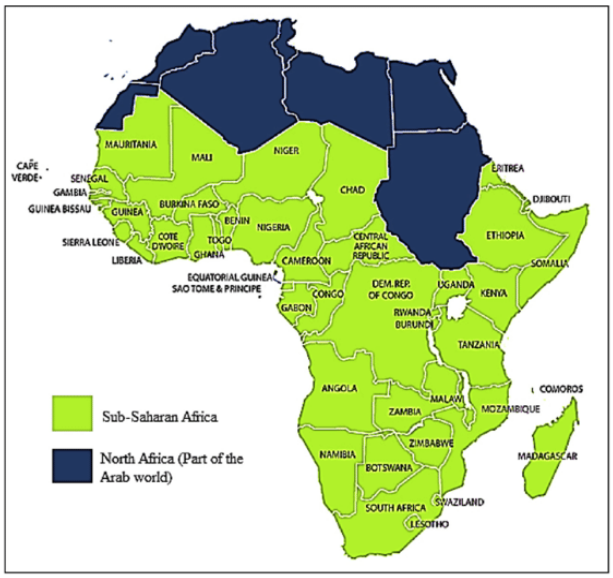

Figure 1. Map of Africa showing the SSA [22]

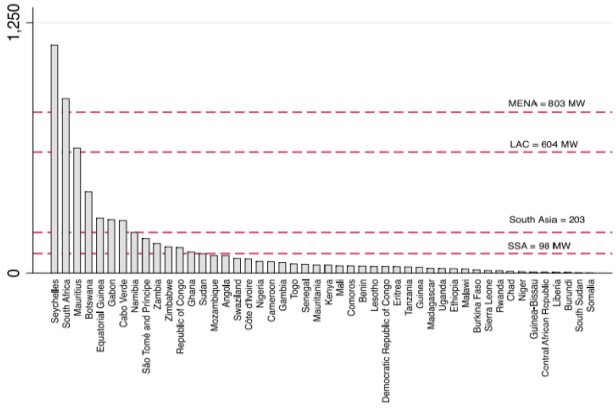

Figure 2. Installed capacity by population size in MW per million people [18]

To overcome the obstacles to electricity access and supply, various SSA countries have been involved in cross-boundary dealing via power pools (PP) and public/private investment. PP are dealings agreement concerning at least two interlocked electricity systems to integrate and maximize their performance in generating and transmitting electric power. The African Development Bank (AfDB) evaluates that the unified regional power deal can reduce Africa's annual electricity costs by a projected $2 billion [17-19] if they are properly managed. Additionally, regional power deals could boost heavy investments in SSA by decreasing the operating expenses of such projects [20]. Presently, there are four PP with an overall capacity of around 15 percent of the entire installed capacity in SSA. The existing PP in order of capacity are the Southern African PP which is the largest; the West African PP; Eastern Africa PP; and the Central Africa PP. Currently, wholesale electricity prices are still on the high side in SSA. The August 2021 market clearing price for the non-off-peak period in SAPP was 15.1 USc/kWh, up from July 2021 of 13.1 USc/kWh. The price for the off-peak period was 6.0 USc/kWh in August, the same as for July 2021 cost [21]. This high price might be a result of a high combination of power generation from exotic crude oil and small energy efficiency of power generation and transmission equipment. In addition, an ill-maintained grid, coupled with unlawful connection and thievery, has caused numerous blackouts on average in almost all the nations of SSA. Thus, scalable off-grid stand-alone renewable-based systems might answer people lacking access to affordable electricity and those who intend to change from a frustrating grid supply to an inexpensive green energy solution.

III. Solar photovoltaic market size

The universal solar photovoltaic (PV) market size was estimated at USD 154. 47 billion in 2020. The market is likely to expand from $199.26 billion in 2021 to $1,000.92 billion in 2028 with a growth rate of 25.9% in the year 2021-2028 [23]. The global impact of COVID-19 has been unprecedented and staggering, with the solar PV industry seeing an undesirable demand shock across the globe amidst the pandemic. The global market unveiled a slower growth of about 2.3% in 2020 as a result of the pandemic. The growth of the solar PV market globally is determined by the gradual shift of the power utility industry from a traditional-based to a renewable sector. Moreover, an increase in awareness toward environmental pollution connected with pollutants from conventional power generation is projected to fuel the progress of the solar photovoltaic market within the projection stretch. But, the absence of

recycling facilities for the recycling of solar to obtain solar panel waste materials globally has also hindered the massive production of the solar PV panel market within the projection interval. On the contrary, the government's initiatives toward minimizing carbon footprints and growth in investment concerning renewable energy infrastructure are projected to offer profitable choices for the major players to sustain their position in the solar photovoltaic market in the future years. The solar PV system market can be categorized based on the technology used, type of grid, class of the end user, and region. For simplicity, the details of various classifications are summarized in Figure 3.

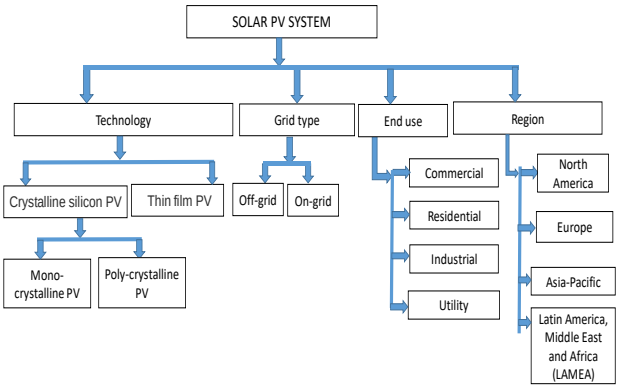

Figure 3. Classification of solar PV system

Concerning the technology used, the solar photovoltaic panel market is divided into crystalline silicon (c-Si) and thin film. Crystalline silicon is the leading semiconducting substance utilized for the fabrication of solar cells which can be gathered to make solar panels that transform solar energy to direct current (dc) electrical energy. c-Si cells are acquired from thin slices of silicon (wafers) 160-240 µm thick, which are usually cut either from a single crystal or a block. [24]. The produced crystalline cell is usually a function of the silicon wafer manufacturing process. Crystalline silicon-based solar photovoltaic (PV) is the go-getter of the photovoltaic energy market dating back to its uncovering in the 1950's up to till date. In the last era, the percentage portion of crystalline silicon solar PV has always been between 80 and 90% [25].

For numerous eras, poly-crystalline has ruled the solar PV market while, in the last years up till the present, mono-crystalline silicon is still the dominant solar PV material. The supremacy of crystalline silicon solar PV can be linked to its early invention and the parallel blossoming of the micro-electronic manufacturing industry [25]. Furthermore, other favorable properties of silicon and silicon cells for its blossom consideration in solar photovoltaic panel production are illustrated in Figure 4. Based on the grid type, the solar PV market is categorized into on-grid which is also known as grid-tied and off-grid solar PV systems. On-grid solar PV system is one in which the solar power system is linked to the utility network using grid-tie inverters while the off-grid solar PV system is a system that operates autonomously and the electricity users are not connected to the main electric grid network. The number of components in an off-grid solar PV system is lesser in comparison to an off-grid solar PV system which implies that the on-grid solar PV system is cheaper than the off-grid solar PV system because of the exclusion of storage battery, generators, and complex electronic control units. However, the off-grid solar system is in an area where grid electric power is either not stable or not available at all.

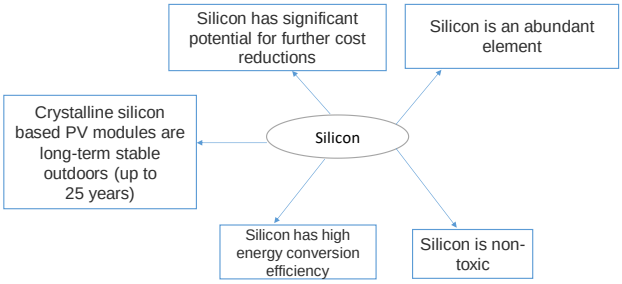

Figure 4. Favorable properties of silicon and silicon cells for its blossom consideration in solar photovoltaic panels production

Some documents/certificates that needed to be submitted to the concerned electric utility company before approval can be given for the connection to the electric grid purposely for the utility company to guarantee the safety and integrity of their power network while connecting on-grid solar PV to it.

It is worth noting that in an on-grid solar PV system, the grid-tied inverter will be automatically shut down in the event of any power failure from the main grid or when the main grid is down, and this phenomenon is referred to as "anti-islanding" protection. Its chief aim is to keep the technical personnel harmless from being killed or injured by the solar power system while the main grid is un-energized. The representation of both on-grid and off-grid solar PV systems showing the required components is presented in Figures 5 and 6.

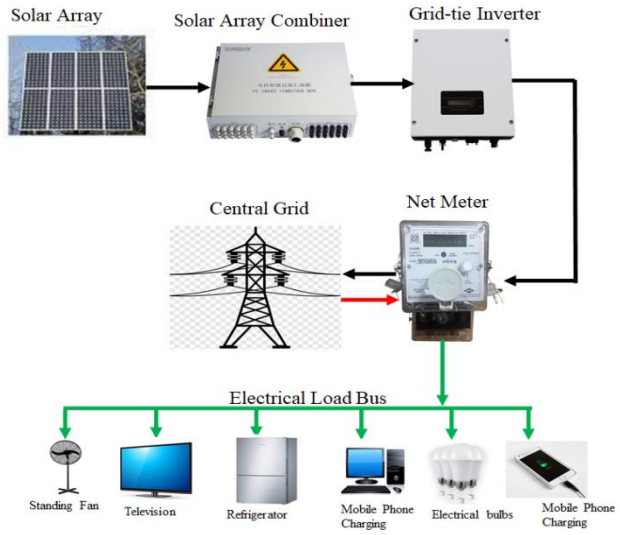

Figure 5. On-grid solar PV system architecture

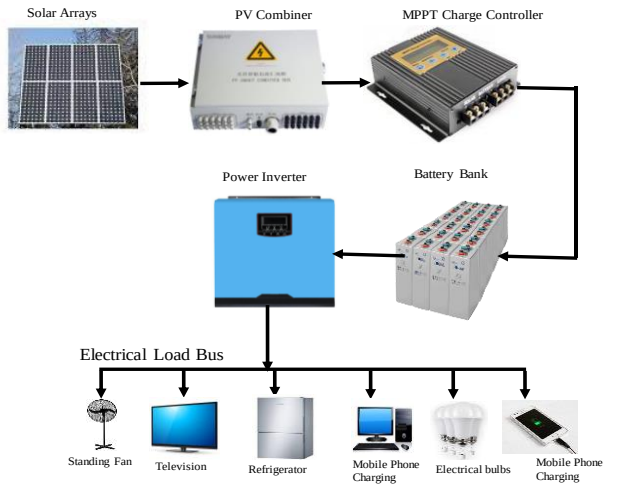

Figure 6. Off-grid solar PV system architecture

According to end users, it can be further fragmented into residential, commercial, industrial, and utilities. Solar PV has experienced a considerable mean annual growth rate in the last decade. The rapid fall in the price of solar PV has been made possible with the help of various federal policies like the Solar Investment Tax Credit (ITC) to encourage the mass installation of green energy in the United State and several similar policies globally. Likewise, the continuous increase in electricity demand across different public and private sectors has further reduced the cost of the solar PV system. It was reported in the IEA, 2019 that 58% of solar PV sizes were utility-scale schemes (347 GW), 30% were commercial systems (176 GW), while 12% tallied to domestic systems (74 GW) (Rodríguez, 2021) as illustrated in Figure 7.

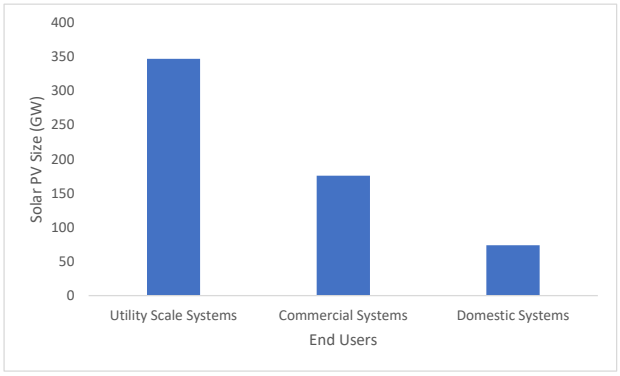

Figure 7. Solar capacity by segment

IEA 2019 report has revealed that about 627 GW of solar PV were installed across the world before the start of 2020. 18 countries installed at least a minimum capacity of 1GW of solar PV and 9 countries achieved the milestone of above 10GW aggregate solar PV capacity by 2019 [26]. Market-wise, China sustained the headship being the first world PV market. But, if we relate the progression of yearly connected size by country and region, as presented in Figure 8, China's headship was destabilized in 2019. Likewise, the distributed solar PV capacity growth by country/region [27] is presented in Figure 9.

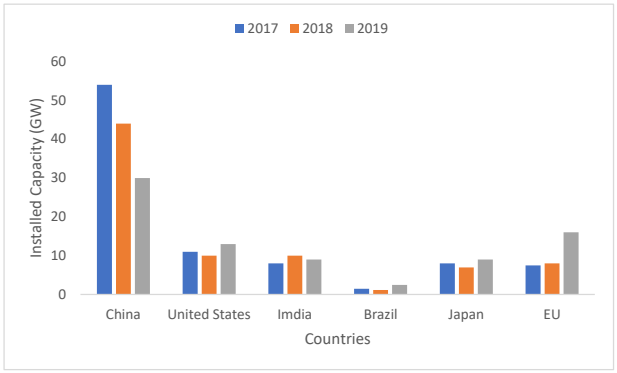

Figure 8. Net solar photovoltaic capacity additions

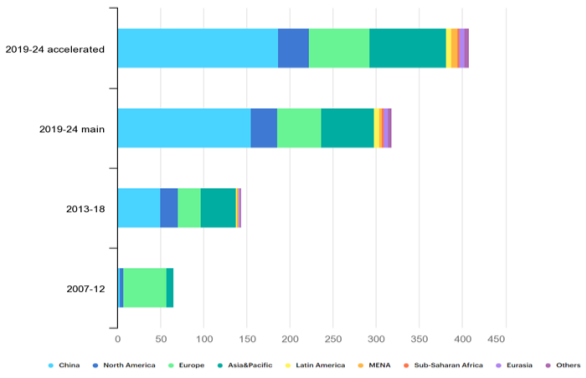

Figure 9. Distributed solar PV capacity growth by country/region

In addition, the key solar PV industry participants include Canadian Solar Inc., Tata Power Solar Systems Ltd., Wuxi Suntech Power Co. Ltd., BrightSource Energy Inc., Nextera Energy Sources LLC, SunPower Corporation, Waaree Group, Jinko Solar, Trina Solar, SunPower Corporation and ReneSola among others. To stay competitive in the global solar PV market, major players are embracing several strategies like product launches, agreements, and investment strategies. For instance, JA Solar launched a 415 W solar module with an efficiency of 21.3% in the year 2021 which was largely used for residential and commercial solar PV projects which enhanced the product portfolio of the company. Additionally, an 800 W solar panel named Jumbo was launched by JA Solar in August 2020, which subsequently strengthened the product portfolio and positioned the company in the Global solar panel business.

IV. Business models for rural electrification

A Business model is a masterful matter in the area of provision of reliable, efficient, and sustainable electricity access, especially in the off-grid areas of developing countries [4]. A traditional model with a tariff-based revenue generation process is usually expensive for a typical rural household whose average daily income falls between $1.9-2. Most of the successful profit-oriented business cases are usually based on pico-solar solutions with low capacity, and little capital costs, coupled with micro-loans which are usually provided by local bankers. Operation of larger-scale solar PV mini-grid projects is quite limited due to its associated high risks as a result of high up-front money coupled with uncertain demand for the daily produced or generated electricity. In addition, the solar mini-grid infrastructure management must balance hourly.

Canadian Solar Inc electric power generation with power consumption to ensure grid stability and prevent frequent blackouts. To eliminate the associated costs (distribution, transmission, and maintenance of grid infrastructure) of solar mini-grid for off-grid rural electrification, Pay-As-You-Go (PAYG) model is usually adopted for rural off-grid electrification, especially in Sub-Saharan Africa (SSA). In the PAYG business model, electrical energy will be generated at the point of consumption.

IV.1. Pay-as-you-go (PAYG) model

PAYG companies usually bank on renewable energy sources (largely solar) in which electricity is produced at the point of consumption (in the case of solar PV, energy is produced from a solar panel installed on the roof of the customer. The costs of the system are usually between $16 for portable lanterns to $151–300 for small home systems and up to $1,000 for larger home systems that power a host of consumer goods [28]. The PAYG model is not only used as a financing solution but has also appeared as a widespread business novelty that provides online repayments in a workable manner using present information technology and improved mobile connectivity, to make the system further affordable. The model has special circuitry to remotely block any customer in case of default payment for the service. This helps in reducing the transaction cost of collecting the payments to minimize the investment risk associated with financial losses from collecting cash payments [29-32]. The cost-effectiveness and tractability of allowing lesser repayments have made PAYG a hopeful model for connecting electricity consumers whose incomes are irregular [28-29]. Among several models that can offer decentralized solar PV, PAYG-based SHS can offer ownership via flexible repayments coupled with systematic monitoring and maintenance which has been a major concern with promptly deploying the decentralized solar system in previous times [33-34]. Most African countries have seen the greatest uptake of PAYG systems in the past few years [35-36]. The root of the PAYG model in Sub-Saharan Africa is Kenya which has up to 500,000 customers [29]. Its successful implementation particularly in East African nations (Rwanda, Tanzania, and Kenya; West African countries (Nigeria, Ghana, Senegal, Cote d'Ivoire, and Benin) has confirmed the potentiality of businesses to leverage long-term linkages with customers to vend and upgrade solar PV products.

IV.2. PAYG SHS delivery models

PAYG utility providers generally use Manual (cash), Mobile Phone Credit (Airtime "Top Up), and mobile payment (Mobile Money) for tariff collection. Manual payments require an agent to collect cash and activate systems via Bluetooth, cable, or SMS code [37]. Mobile Phone Credit allows customers to pay with mobile airtime, varying by country and mobile network operator (MNO). Mobile Money enables smaller, more frequent repayments from anywhere with a phone signal. Digital

payment methods allow providers to remotely monitor solar PV systems in real-time, centrally manage a large customer base at lower cost, and offer better business effectiveness [38]. Mobile money eliminates the need for customers to travel to energy shops or for providers to set up extensive agent networks.

IV.3. Customer payment methods

GSM chips and software embedded in SHS devices enable communication, monitoring, and remote operations via automated or manual controllers. Devices with machine-to-machine connectivity modules receive payment proof through the mobile network to unlock services and allow electricity flow from the battery to appliances [39-40]. M-KOPA, a profit-oriented firm founded in Kenya in 2011, is an example of a PAYG SHS provider. They sell SHSs to off-grid rural households using an affordable mobile money payment plan over a minimum of 12 months. Their machine-to-machine communication scheme is summarized in Figure 10.

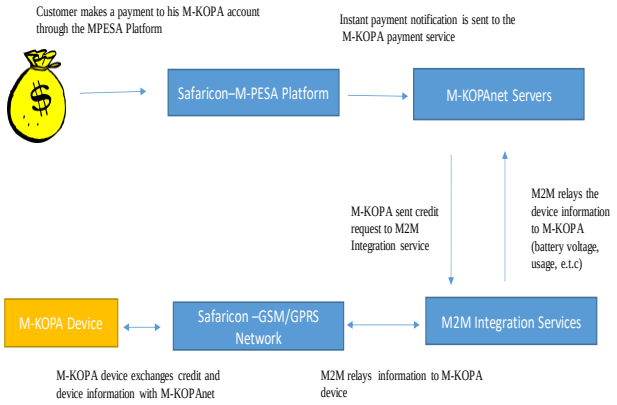

Figure 10. The M-KOPA Machine-to-Machine Communication Scheme [39]

IV.4. Government funding via Public-Private Partnerships

(PPPs) is essential for expanding higher-capacity Pay-As-You-Go (PAYG) Solar Home Systems (SHSs) to impoverished, off-grid rural households in Sub-Saharan Africa (SSA), as these households, often living below $US 1.90 [41], face prohibitive costs for larger systems. While pico-solar lighting is affordable for the rural poor [42-49], consumers overwhelmingly prefer higher-capacity SHSs (around 150 W and above) capable of powering TVs and fans, in addition to lighting and phone charging [42]. The significant payments required for these larger SHSs are likely excessive for poor rural households [39], [50-52], and PAYG providers face increased vulnerability when serving these low-income customers due to personal, social, and political uncertainties. Extending repayment periods from one year to two or three years [53] can strain PAYG companies, which require higher working capital and must meet financial obligations. Even if financing risks are managed, low-income customers might not consistently adhere to repayment patterns [54]. Therefore, governmental support is crucial to de-risk the business environment for PAYG companies serving these communities. It is proposed that governments collaborate with PAYG companies under a PPP (as depicted in Figure 11) to enable poor rural households to acquire larger SHSs, thereby achieving productive electricity uses and fulfilling energy access commitments, particularly in areas deemed un-electrified or economically unviable for grid extension [55-59]. This partnership would involve federal, zonal, state, and local rural electrification boards working with PAYG companies to identify eligible households (those living below $US 0.9), manage installations, and facilitate monetary support from the government, ultimately improving rural electrification reliability, addressing policy insecurities for private enterprises, ensuring revenue certainty for PAYG companies, and fostering greater social recognition in rural SSA. Governments, especially in SSA, must swiftly develop the necessary standards and regulations to enable such business models, ensuring high-quality services and customer satisfaction.

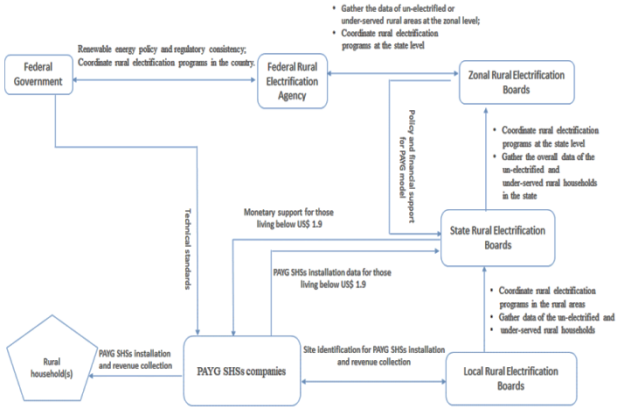

Figure 11. Representation of a possible public-private partnership with SPAYG SHSs provide

IV.5. Development of a scalable pay-as-you-go (SPAYG) model

The initial aim of Pay-As-You-Go (PAYG) Solar Home Systems (SHS) was to electrify the most remote and vulnerable communities in SSA; however, a significant portion of users are from better-off rural and urban segments. For instance, out of 2,054,064 SHS units sold in SSA, 977,902 were through PAYG, with regional breakdowns showing East Africa at 734,484 PAYG units, West Africa at 180,174, Central Africa at 56,088, and Southern Africa at 7,156, while the Middle East & North Africa region saw all 313,174 units sold via outright purchase [60]. This, along with initiatives like Nigeria's plan to provide 5 million SHSs to underserved rural and urban areas by 2025 under the Economic Sustainability Plan (ESP), with beneficiaries paying $US 3.125 per week or $US 8.733 per month for up to 36 months [61], suggests that many households can afford system upgrades as their incomes improve. Current conventional PAYG SHS models are limited as they are non-upgradable and primarily Direct Current (DC)-based, despite most affordable appliances in SSA being Alternating Current (AC)-based, and efficient DC appliances being prohibitively expensive for most rural and urban populations. Recognizing that energy needs increase with income, a Scalable Pay-As-You-Go (SPAYG) SHS model is proposed, allowing customers to upgrade their systems before or after payment completion without returning the initial package, with the core objective of providing an upgradable PAYG system to meet typical rural and urban residential and commercial load demands, accelerating electrification access in SSA, and reducing reliance on costly solar mini-grids.

This Scalable Pay-As-You-Go (SPAYG) model aims to benefit electricity distribution companies by reducing operational stress in low-load areas, enabling prioritized distribution for better revenue, and decreasing maintenance and collection costs. It promises to minimize distribution losses and costs by generating power at the point of consumption, and is expected to combat vandalism, energy theft, and security issues common with mini-grids in SSA. As detailed in Figure 12, new customers can choose a standard SHS or a Scalable Solar Home System (SSHS), anticipating future load demands. SSHS customers can upgrade their systems if they have a good payment record, which is verified by the PAYG operator, who then extends an offer via SMS and a follow-up call. For SSHS, the initial inverter (kW) and charge controller (amps, max DC voltage) capacities must accommodate the specified future load, and the wattage and DC voltage of solar panels for upgrades must be pre-decided and recorded during registration.

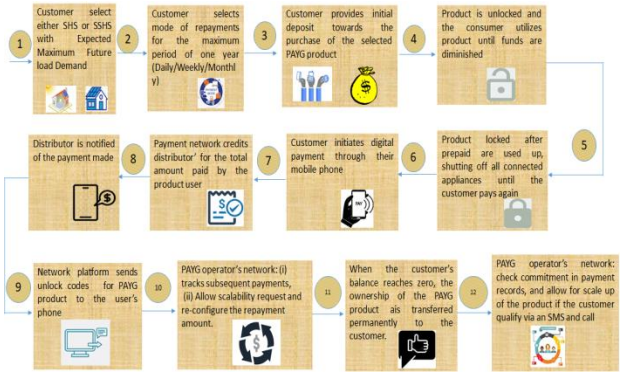

Figure 12. The SPAYG model

IV.6. Method of data analysis

Data analysis involved structured and personal interviews with 50 PAYG SHS customers from CLOUD Energy, d.light, and Sunking Solar in Nigeria, with 10 of these also undergoing personal interviews for more reliable data. Customers were selected if they had been with a PAYG SHS company for at least 4-6 months and had consistent payments. Initially, most users intended to power lights, radios, and charge phones, while a minority aimed to power solar fans and TVs (Figure 13). A larger percentage of respondents earning over N20,000 monthly were willing to upgrade to power fans, TVs, and refrigerators, compared to a smaller percentage of those earning less than N20,000 due to financial constraints (Figure 14). Critically, the largest percentage of both income groups expressed strong willingness to adopt SHS as their primary energy source (Figure 15). This survey suggests that offering upgrade options in PAYG SHS business models will significantly accelerate electrification access in SSA.

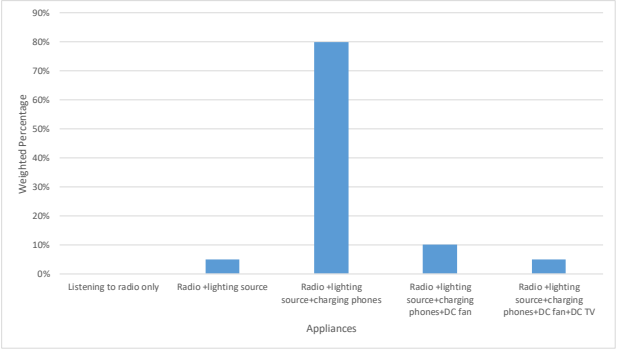

Figure 13. Weighted percentage for SHS sign-up motives

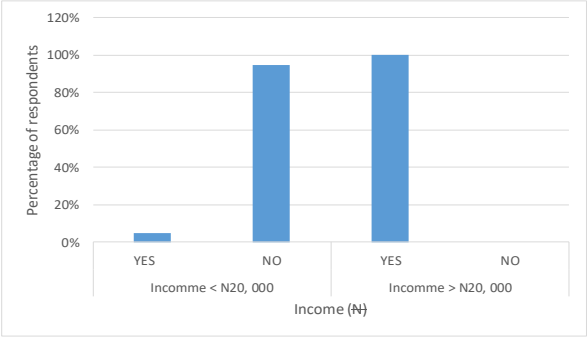

Figure 14. Willingness to upgrade the present SHS package

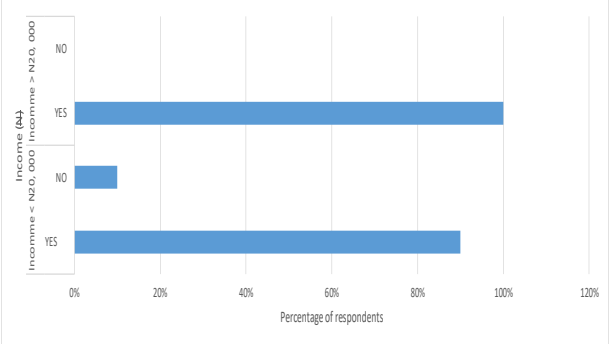

Figure 15. Adoption of SHS as the main primary source of energy

To enhance the viability of the Scalable Pay-As-You-Go (SPAYG) model in SSA, careful collaboration between SPAYG companies and telecom operators is crucial for delivering GSM-enabled services, benefiting both sectors and allowing for investment assessment regarding product longevity, customer lifetime value, and scalability. SPAYG can be a vital tool for improving rural households' economic potential by moving them up the energy ladder. Key recommendations for viability enhancement are outlined in Table 1, emphasizing the need for policy support, innovative synergy, and tactical collaborations to boost renewable energy, especially given SSA's cash-based economy and governmental preference for grid extension. Effective and economical customer sensitization on solar PV and mobile money payment requires partnerships among SPAYG companies, mobile wallet providers, digital investment solutions, and telecommunication providers.

Table 1. Illustrating the viability of the SPAYG model in SSA

	Shareholders			
	Governments	**SPAYG Firms**	**Finance Provider**	**SPAYG firms and telecom operators**
Activities	Encourage PPPs between the federal governments and PAYG companies. Permit SPAYG SHS provider to fulfill the energy access needs and targets. Participate through zonal, state, local governments, in addition to within numerous public entities, to assist PPPs for wider reception and effective electricity services. Oversee the Rural Electrification Fund (REF) which shall be used for the promotion of rural electrification via PPPs.	Partnerships in the areas of design, enlargement, and distribution of different capacities of the SHS. Modify value suggestions to market the products as an asset, proposing stretchy payments and options for the scalability of the product before the completion of the payments. Dissemination of the SPAYG business model among sponsors and consumers.	Provision of extended financing that identifies the economic practicability of excellent services and customer fulfillment.	Validate partnerships for the provision of GSM-enabled SPAYG services.

V. Conclusion

This paper has presented a review of the current scenarios of rural electrification in Sub-Saharan African countries. It also examined different business models that could be employed in rural electrification projects. Looking at the future, for rapid acceptance and deployment of solar home systems for rural areas electrification, the study proposed the Scalable-Pay-As-You-Go funding in addition to the public-private partnership funding approach. It is important to state that understanding of the operating condition and the desire of the customers are indispensable, principally in the rural areas where the larger percentage of low-income earners reside. An effective business model would make sure that the regulations and guidelines are met, and a requisite revenue that can take care of the overall costs of the project and provide expected return can be made.

The establishment of a micro-funding is usually a key instrument for the growth of SHSs, and likewise, the PAYG remittance technique which is usually a major business model revolution and has ushered in the high absorption of the technology by the off-grid rural and urban consumers in SSA. PAYG business model offers an appropriate vehicle to transport dependable green energy to off-grid customers due to integrated superior product and approachable maintenance feature tendered for inexpensive repayment over time of a refined payment platform and steadily combining telecom sector. In addition, a public-private partnership between the federal government and PAYG companies is proposed that can significantly promote speedy electricity access especially, for poor off-grid rural households.

The practical development, maximization of telecommunications, and the growing acceptance of mobile money in SSA countries are worthy to be included in the policies to attain the goals of collective electricity access and an uninterrupted power supply for all through the SPAYG model. Concurrently, SPAYG

companies would have a major part to play in continual support and discussion with the government concerning business model development and modification to guarantee the feasibility of the SPAYG model to emerge as a reliable model for capacity extension and offering financial services in addition to function as an off-grid electricity solution.

Declaration

- The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.
- The authors declare that this article has not been published before and is not in the process of being published in any other journal.
- The authors confirmed that the paper was free of plagiarism

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