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PATHWAYS TO ELECTRICITY ACCESS EXPANSION IN SOUTH SUDAN: OFF-GRID AND MINI-GRID MARKET ASSESSMENT

ESMAP
Energy Sector Management Assistance Program

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Pathways to Electricity Access Expansion in South Sudan: Off-Grid and Mini-Grid Market Assessment

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ABOUT ESMAP

ESMAP is a partnership between the World Bank and 24 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector. Through the World Bank Group (WBG), ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable, and modern energy for all. It helps to shape WBG strategies and programs to achieve the WBG Climate Change Action Plan targets.

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List of Acronyms

AECF	Africa Energy Challenge Fund
ATP	Ability to Pay
EAC	East African Community
FGD	Focus Group Discussion
JEDCO	Juba Electricity Distribution Company Ltd
KII	Key Informant Interviews
kW	Kilowatt
MoED	Ministry of Energy and Dams
MTF	Multi-Tier Framework
MW	Megawatt
PAYGo	Pay-as-you-go
SDG	Sustainable Development Goals
SEDC	State Electricity Distribution Companies
SEforALL	Sustainable Energy for All
SHS	Solar Home System
SL	Solar Lantern
SLS	Solar Lighting System
SSP	South Sudanese Pound
SSEC	South Sudan Electricity Corporation
TAM	Total Addressable Market
TSM	Total Serviceable Market
REA	Rural Electrification Agency
VAT	Value Added Tax
W	Watt
WTP	Willingness to Pay

Terminologies

There are no universally accepted definitions of solar lanterns, solar lighting and solar home systems. However, this study adopts the definitions used by the World Bank Multi-Tier Framework Energy Access Diagnostic Reports (Dubey et al., 2020). These typologies are defined as follows:

Solar devices are classified into three types based on the number of lightbulbs and the type of appliances or electricity services a household uses. This typology is used to assess the Capacity attribute and related tier.

Solar Lanterns power a single light bulb with/without mobile charging and/or radio.

Solar Lighting system multiple light bulbs with/ without mobile charging and/ or radio.

Solar Home System Multiple Lightbulbs and additional appliances e.g television, fans and refrigerators.

There's no universal definition distinguishing mini-grids from micro-grids, the two-terms are often used interchangeably. However, for this study, we adopt a definition:

1. Micro-grids or Pico-Grids: A generation capacity below 10 kilowatts (kW).

2. Mini-grids: a generation capacity from 11kw and above.

Executive Summary

Introduction

The Republic of South Sudan is a land-locked country located in East-Central Africa with a population of 11.4 million people. In 2020, the World Bank, in response to South Sudan's transitional government's request, set up the Pathways to Electricity Access Expansion in South Sudan ASA (Advisory Services and Analytics). As part of the initiative, the World Bank commissioned this study – the Off-grid and Mini-grids Market Assessment. The study had four specific objectives, namely:

1. To analyse the demand and supply of modern off-grid technologies,
2. To assess the local financing market for standalone solar PV and mini-grid services,
3. To review the enabling environment and public/ donor-led initiatives and,
4. To analyse barriers and opportunities to scale up the standalone solar PV and mini-grid markets.

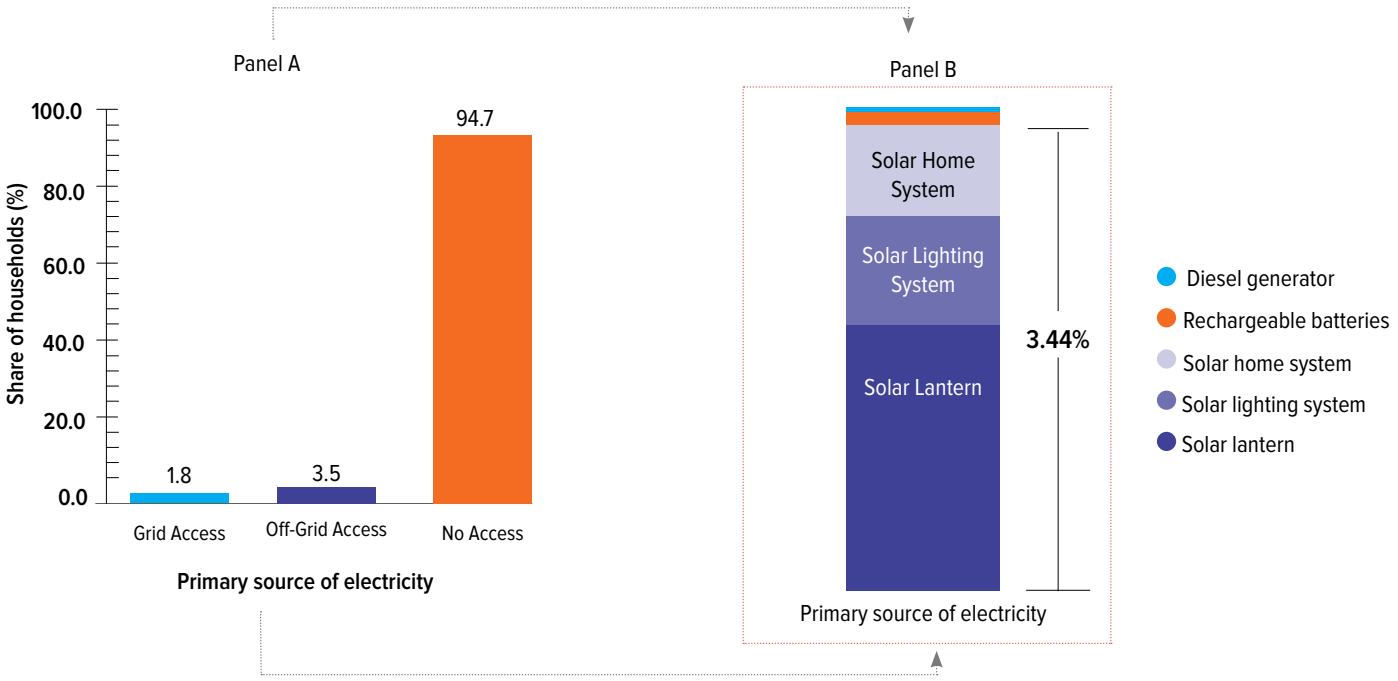
We undertook a national household (n=1,261) and institutional (n=281) survey to meet these objectives. Additionally, we conducted ten (10) focus group discussions (one in each state), 22 key informant interviews and an extensive literature review to complement the quantitative data.

Study findings

According to the study, only 5.4% of the South Sudanese population have access to electricity, slightly higher than the access rate of 4.2% reported in 2017. The study also indicates that 94.7% of households do not have access to any electricity source, while only 1.8% are connected to a mini-grid, 0.03% use diesel generators and 3.44% use off-grid technologies, as shown in Figure 1 below. Off-grid technologies included solar lanterns, solar lighting systems, solar home systems, and rechargeable batteries.

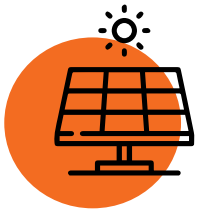
FIGURE 1

Access to electricity and off-grid technology, nationwide



5.4%

of people nationwide have access to electricity, slightly higher than the access rate of 4.2% reported in 2017.



1.72%

of rural households have access through off-grid solar products such as solar lanterns and solar lighting systems.

Off-grid solar companies in South Sudan focus on serving large institutions and commercial customers, who make up over

80%

of their sales

There were significant disparities between urban and rural electricity access rates. While urban households have a higher rate of electricity access, solar PV is the most popular off-grid source of electricity across both urban and rural households. Most rural households (98.3%) have no access to electricity, but 1.72% have access through off-grid solar products such as solar lanterns and solar lighting systems. In urban areas, about 70% of households have no access to electricity, while the remaining 30% have access through micro and mini-grids (13.99%) and solar PV technologies (16.21%).

Proximity to off-grid solar retail access points such as electronic and solar company shops are vital to improving access to off-grid solar products. The study revealed that rural households have limited options for purchasing off-grid solar devices, with only two points of purchase available to them - local electronic shops (70.4%) or other channels (29.6%), such as purchases made from outside the country or through a relative. On the other hand, urban households have more choices for buying off-grid solar products, including electronic shops (64.7%), supermarkets (15.1%), hawkers (10.1%), and authorised dealers. Additionally, rural households reported having to travel longer distances, about 10.3 hours, to their point of purchase compared to 2.3 hours for urban households.

The **primary obstacle** to accessing off-grid solar products is their **high cost**, which is seen as a barrier by at least 70% of households in rural and urban areas. This impediment could be overcome through flexible payment methods, with 54% of urban and 29% of rural households willing to pay for solar solutions in instalments. However, off-grid solar companies in South Sudan only offered flexible payment options to a few known NGO employees to avoid the high payment default risk. As a result, no rural households with a standalone solar product had access to any payment options/consumer financing, while slightly more than 15% of urban households had access to the payment/financing options.

The **second hurdle** is the **lack of awareness**, with 8% of urban and rural populations reporting a lack of knowledge about solar devices.

The **third barrier** to greater penetration of solar devices in South Sudan is **poor consumer perceptions** of solar product quality.

Most of the respondents are dissatisfied with the quality of their solar products due to power quality and device functionality issues. Only 22% of the respondents are happy with the quality of power. Those unsatisfied indicated that the solar devices could not power all household appliances and power running out at night. Additionally, around 16% of households reported device malfunctions. Customer dissatisfaction and product malfunctions are attributed to the low level of after-sales services, where only 21.1% of households received a warranty.

Off-grid energy companies are essential to expanding electricity access. However, the South Sudan off-grid market is nascent and characterized by few

off-grid energy companies. There are about fourteen off-grid energy companies in South Sudan, and their services include i) selling solar products, ii) engineering, procurement, and construction (EPC), iii) independent power production (IPPs) and iv) developing mini-grids. Off-grid solar companies in South Sudan focus on serving large institutions and commercial customers, who make up over 80% of their sales. They prefer serving international NGOs and aid organisations operating in the country since these organisations can readily pay, unlike households. This leaves the household market underserved. These companies do not use extensive marketing campaigns but rely on referrals and inbound clients.

Access to finance is vital for enhancing electricity access. Unfortunately, both consumers and off-grid solar companies lack access to financing. Both foreign and local South Sudan banks are reluctant to offer loans for energy-related activities. The microfinance (MFI) sector is also underdeveloped, and existing MFIs are mainly available in urban areas. The most common source of loans is through Village Savings and Loan Associations (VSLAs), established by NGOs, particularly in rural areas. Mobile money services, crucial for consumer financing of off-grid solar products, are still in their early stages due to a weak telecom sector. Only 8.5% of households have mobile bank accounts, making it difficult for financing institutions to reach more customers and for solar companies to sell their products.

Institutional access to electricity is also low in South Sudan. Out of 281 institutions surveyed in the ten states of South Sudan, educational institutions had the least access to electricity, with a rate of 7.39% (n = 74). This was followed by government and NGO offices at 16.53% (n = 72), while health facilities had the highest access rate at 69.46% (n = 73). Given the currently low levels of energy access for South Sudanese institutions, this study estimated the total additional generation capacity and investment needed to electrify all health, education, and government institutions. The analysis shows that an additional investment of USD106,869,570 is required for hybrid off-grid solutions, including solar PV panels, batteries, and backup generators, to electrify all institutions without electricity access.

Conclusions

This study reveals potentially high demand for off-grid solar products in South Sudan due to the low national electrification rate of 5.4%. However, the lack of affordability and availability of off-grid products hinder consumers from acquiring these products. Consumer financing may be a solution, but the lack of traditional consumer financing options and an underdeveloped mobile money sector that doesn't support PAYGo models further alienate potential consumers.

The supply side for off-grid solar products is similarly underdeveloped due to limited distribution channels, a lack of quality verified products, and a small consumer market willing and able to pay for products. Suppliers also lack financing and face an unfavourable regulatory environment, with a 30% import duty charged on off-grid solar products, which impedes electricity access expansion through off-grid solutions. High distribution and transportation costs are additional challenges faced by companies in this sector. Companies also have limited access to working and growth capital because of high-interest rates (30%) and collateral requirements, making obtaining loans from formal financial institutions difficult.

Recommendations

- Remove the 30% import duty and value-added tax (VAT) on off-grid solar products and appliances to make them affordable to end users.
- Adopt quality standards for off-grid solar products and applications to protect consumers from substandard products and encourage high-quality, durable products in the market.
- Develop foundational regulations to support the development of the mini-grid sector. The regulations should include guidance on the licensing and permitting processes and tariff-setting regulations.
- Develop a national electrification strategy that defines the role of off-grid solutions.
- Design and implement subsidies for off-grid solar products. Two types of subsidies are recommended:

  a) A Results-Based Financing (RBF) facility targeting the promotion of quality verified Tier 1 and above off-grid products and,

  b) Grants to be awarded to commercially viable off-grid solar companies on a competitive basis, in order to de-risk their expansion into underserved rural areas.

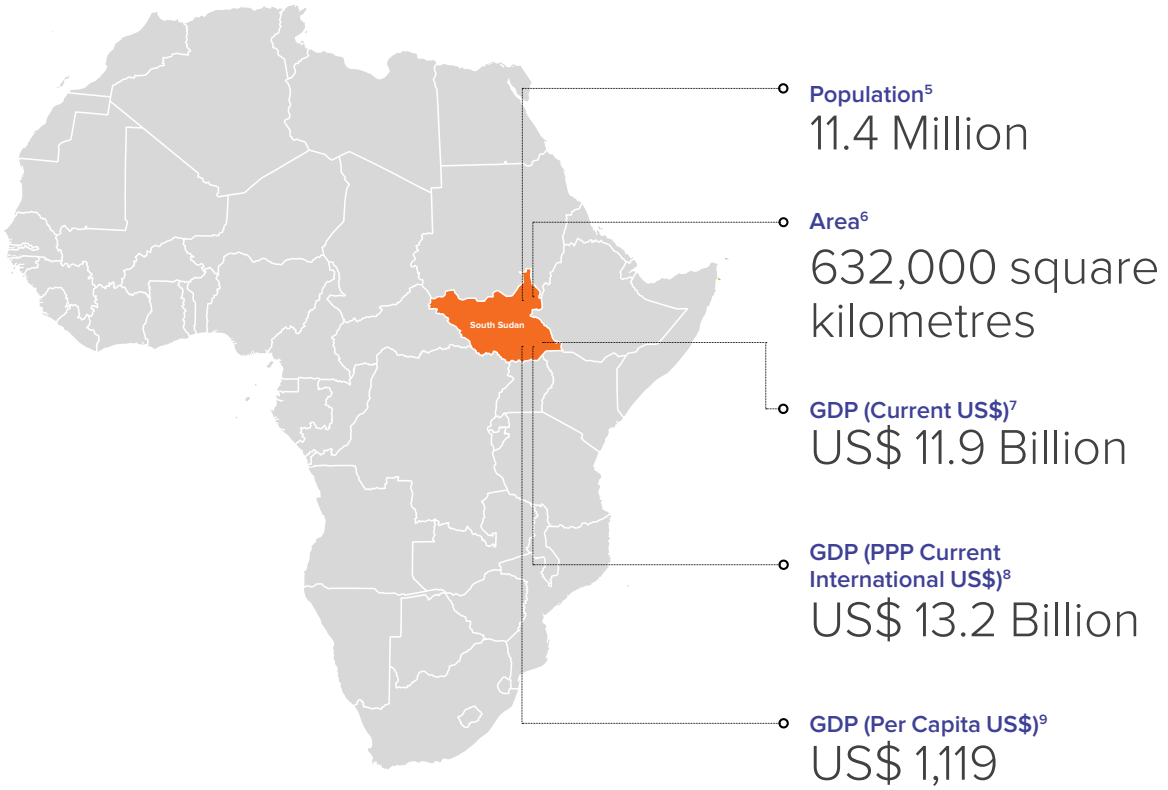
1. Introduction

1.1 Country Context

The Republic of South Sudan is a land-locked country in East-Central Africa and part of the East African Community (EAC). The nation gained independence from the greater Sudan through a referendum in July 2011, making it the youngest country in the world. According to the United Nations Population Fund, South Sudan has a population of 11.4 million, with an estimated growth rate of 0.9% for 2015-2020 (United Nations Population Fund, 2022). The country covers an area of approximately 632,000 km2, ranking 43rd in the world (African Development Bank, 2013). It is divided into ten states, two administrative regions, and one area with special administrative status. Juba, the capital city of South Sudan, hosts about half a million people and a majority of the economic and financial institutions.

The national real GDP growth rate was 7.4% in 2019, and according to the African Development Bank, the country went into recession in 2020, with the growth rate dropping to -4% (African Development Bank, 2022) due to the COVID-19 pandemic. The pandemic negatively impacted the main income-generating sectors, including the service, agriculture, and oil industries, accounting for 6.1%, 70% and 15% of the country's GDP, respectively (African Development Bank, 2020b).

FIGURE 2:
South Sudan Country Profile



South Sudan is considered poor, with 82% of the population living below the poverty line, defined as those earning less than US$ 1.90 daily (World Bank, 2023c). Due to the COVID-19 pandemic, living standards declined further, with 51.2% of respondents in a World Bank survey reporting lower earnings (World Bank, 2022d). Declining access to essential services and increasing food insecurity risks have worsened due to the pandemic's production and supply chain disruptions (World Bank, 2023c).South Sudan is estimated to have one of the lowest electricity access rates in the world, coupled with very high electricity tariffs and unreliable supply among the few that are connected to the existing micro and mini-grids (Energy Assistance Management Program, 2021). The survey carried out under this study confirms this and provides more insights into this challenge. South Sudan is off track to achieving Sustainable Development Goal number 7 (SDG-7), and the lack of access to widespread, reliable, and affordable electricity is a binding constraint to socio-economic development. The displacement of people due to the conflicts and flooding in the country further complicates the energy access challenges. Currently, nearly 2 million people in South Sudan have been internally displaced, and an additional 2 million have fled the country in search of safety. Lack of access to modern electricity is particularly dire among people living in refugee or resettlement camps, with most relying on kerosene, charcoal, firewood, and animal waste for their energy (UNHCR, 2019).

1.2 Study Rationale

Over the past decade, the World Bank Group has initiated various engagements with the Government of South Sudan to promote social and economic growth. After independence in 2011, the Bank launched the energy sector programme with the government. Unfortunately, the initiative was affected by a resurgence of violence and changing national priorities. Nevertheless, the World Bank provided resources between 2011 and 2014 to initiate policy dialogue supplemented by an energy sector diagnostic which birthed the 2013 Energy Sector Strategy Note (ESSN). During the civil war of 2013 – 2020, the Bank supported various programmes that responded to the crisis, including supporting stabilisation efforts, recovery, and peace initiatives. The priority then was to support emergency-related basic needs and livelihood options to mitigate further escalation of the crisis. In 2020, the Bank, in response to the transitional government's request, set up the Pathways to Electricity Access Expansion in South Sudan ASA (Advisory Services and Analytics).

The initiative aims to update the energy sector diagnostics and analytics to inform the re-engagement in South Sudan's energy sector. Additionally, the programme will develop options for expanding electricity access to households, health facilities, schools, and enterprises. The Advisory Services and Analytics have four components:

1. Updating the 2013 Energy Sector Strategy Note (ESSN)
2. A least-cost geospatial electrification analysis
3. An off-grid market assessment
4. A roadmap for future World Bank's Investment to increase electricity access in South Sudan

The World Bank, therefore, commissioned this study – the Off-grid and Mini-grids Market Assessment, to help inform future World Bank energy sector engagements in South Sudan. The scope of work includes

i) quantitative analysis of demand and supply of standalone solar systems and mini-grids;

ii) assessment of the local financing markets for standalone solar PV and mini-grid services;

iii) review of the enabling environment; and

iv) identification of barriers and opportunities to stimulate and expand the standalone solar PV and mini-grids markets in South Sudan.

Four specific tasks have been carried out under this assessment:

- **Task 1:** Analysis of demand and supply of modern off-grid technologies;
- **Task 2:** Assessment of the local financing market for standalone solar PV and mini-grids services;
- **Task 3:** Review of the enabling environment and public/donor-led initiatives;
- **Task 4:** Barriers and opportunities to scale-up the standalone solar PV and mini-grids markets.

1.3 Approach and Methodology

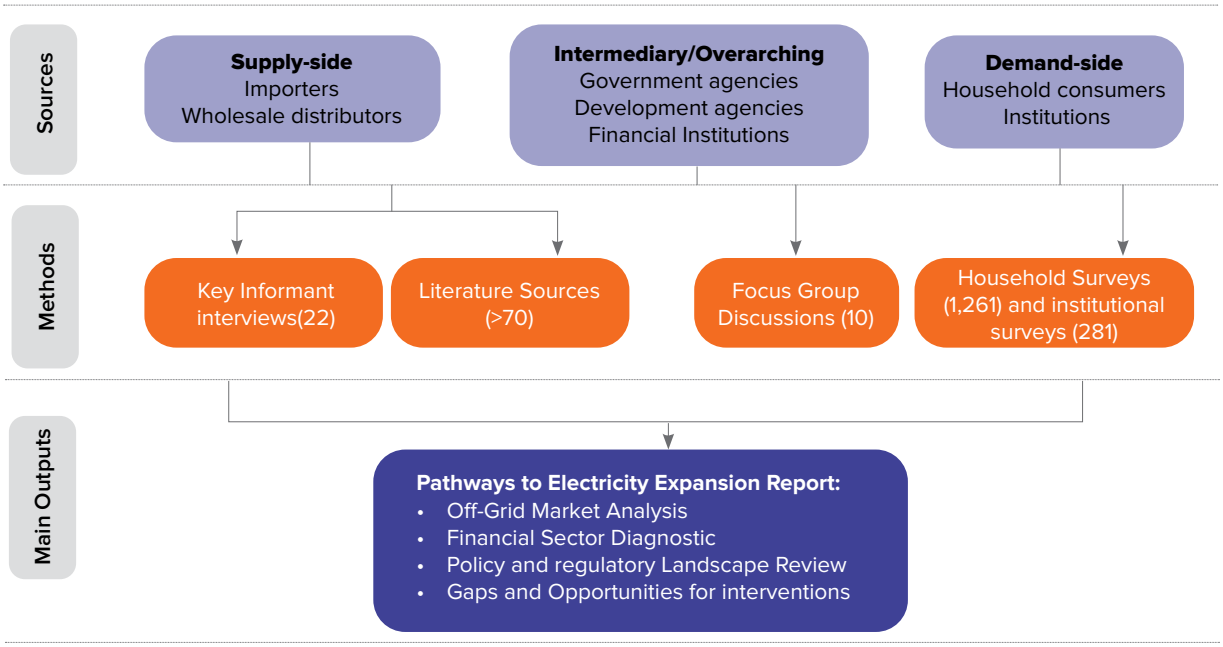
To meet the study objectives, data was gathered from actors across the energy services value chain as below,

i) Supply Side (mini-grid developers and solar off-grid companies),

ii) intermediaries and overarching actors (finance institutions, government and regulators, non-governmental organisations) and

iii) Demand Side (end-users including households and institutions) as shown in Figure 3.

FIGURE 3
Summary of the Approach and Methodology

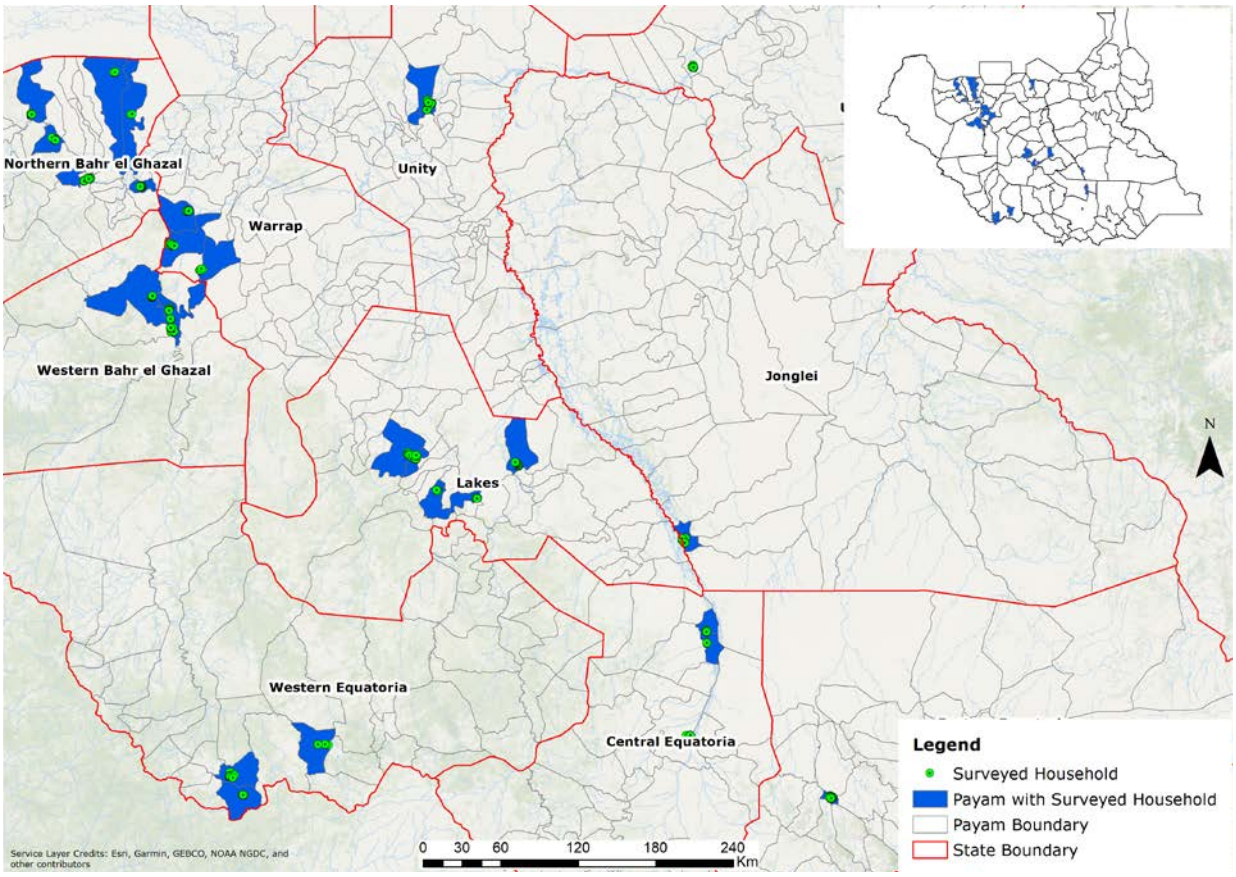


For the survey design, the household sample selection was stratified across the urban-rural population, and the target sample size was calculated through Cochran's formula. The urban and rural population sample sizes were calculated independently, yielding a sample size of 634 per locality (total = 1,268). However, the rural market for solar products was assumed to be heterogenous, so the sample size was revised to further oversample for urban households. A total of 1,261 households, 778 urban and 431 rural, were interviewed (Figure 4) against a target of (761 urban and 507 rural households). For institutions, 281 institutions were surveyed against a target of 140 across South Sudan's ten (10) states.

To supplement the information obtained from the household and institutional surveys, ten (10) focus group discussions (FGD) were held, one in each state. Qualitative data was also gathered through 21 key informant interviews with intermediaries and overarching actors such as government and financial institutions and a review of literature sources.

FIGURE 4

Summary of the Survey



#	State	Target Rural HHs	Achieved	Target Urban HHs	Achieved
1	Central Equatoria	90	78	72	83
2	Eastern Equatoria	19	0	78	79
3	Jonglei	0	0	78	65
4	Lakes	57	60	65	75
5	Northern Bahr El Ghazal	113	125	78	82
6	Unity	19	36	78	71
7	Upper Nile	38	0	78	69
8	Warrap	38	46	78	79
9	Western Bahr El Ghazal	76	80	78	90
10	Western Equatoria	57	58	78	85
	Grand Total	507	483	761	778

2. Electricity Sector in South Sudan

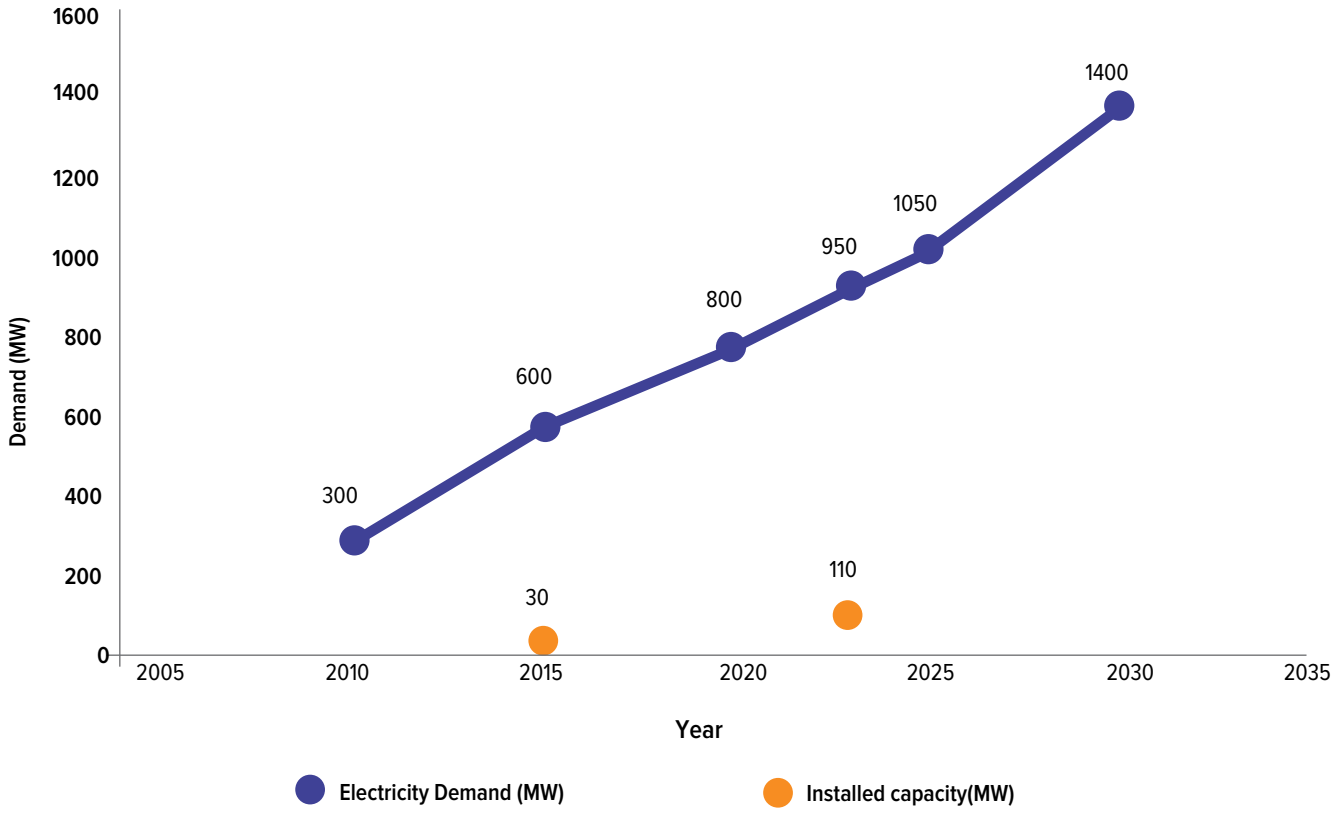
2.1 Status of Electricity Generation in South Sudan

Most of South Sudan's electricity supply and distribution infrastructure is in Juba, with very little working equipment in other cities and rural areas. Juba Electricity Distribution Company Limited (JEDCO) is Juba's sole electricity service provider and the only functional distribution utility in the country. JEDCO was established in May 2018 as a Public Private Partnership, with the EZRA having 52% shareholding and South Sudan Electricity Corporation (SSEC)/ Ministry of Energy and Dams (MoED) having 48% shareholding. The country's total installed power capacity is approximately 103 MW, all from thermal sources, of which around 76.5 MW is operational, but only around 34.5 MW is available to the public. The remaining 42 MW serves the Paloch oil field as captive power. Other generation plants attached to isolated distribution networks in smaller cities and towns, including South Sudan's state capitals such as Wau, Malakal, Rumbek, and Yambio, and other towns such as Yei, are non-operational due to lack of adequate maintenance and destruction during the civil war. South Sudan does not have a transmission network, and even before the conflict, the power system consisted entirely of isolated distribution grids.

Previous reporting on the electricity access rate in South Sudan indicates that the national access rate in 2017 was 4.2% (Ministry of Health, 2017). The projected electricity demand in the country (estimated to have increased to 800 MW in 2020) outstrips the supply of 110 MW (Figure 5 below) (Ministry of Energy and Dams, 2017). Demand is expected to rise to 1,400 MW by 2030 (Ministry of Energy and Dams, 2017), signalling an urgent need for increased power generation and improved electricity distribution coverage.

FIGURE 5

Expected increase in electricity demand in South Sudan (MW)



2.2 The emergence of the off-grid market

To cope with the limited infrastructure, a subsect of the population has opted for off-grid electricity options, including diesel generators and solar products (Lemi & La Belle, 2020). A 2020 study reported that Juba's off-grid installed generation capacity was 28.93 MW, slightly lower than EZRA's 33 MW installed capacity (Lemi & La Belle, 2020). About 99% of the 28.93 MW off-grid capacity is generated from diesel generators, and only 1% is generated from solar energy. Commercial enterprises, industries, non-governmental entities, and public institutions such as education and health centres mainly run off-grid diesel generators. The hotel sector is estimated to have the largest installed capacity accounting for about 62% of the total off-grid capacity (Lemi & La Belle, 2020). For domestic settings, an assessment of electricity access in Juba in 2018 highlights that the demand for solar devices in the city outstripped the demand for diesel generator units between 2013-2017 (Tiitmamer & Anai, 2018).

The pace of off-grid standalone solar product penetration in South Sudan is still unclear. According to GOGLA's reports on the sales volumes of affiliate members, South Sudan has recorded cumulative sales of 142,821 units since 2016. About 55.7% of these sales were recorded in 2021 alone (GOGLA, 2021). Over 85% of these sales have been quality-verified products primarily sold to the humanitarian sector. For the general market, an estimated 80-90% of solar lighting products are sold in Juba (Altai Consulting, 2014).

Data on micro and mini-grid development in South Sudan is scarce. However, government sources indicate that rural micro and mini-grids exist in a few rural centres in South Sudan, including Yei (1.5 MW), Kapoeta (0.8 MW), and Maridi (0.8 MW), with a total capacity of 3.1 MW which are not functional. Other ongoing initiatives in the off-grid sector are noted to be donor-funded, as indicated in Table 1 below.

Table 1: Ongoing Initiatives and Programmes in the off-grid energy sector

#	Name	Objectives and Description	Lead Partners
1	Peace Renewable Energy Credit (P-REC)	To fund solar electrification of the Malakal Teaching Hospital by transferring renewable energy credits generated through a solar power plant operated by IOM. The renewable energy credits generated from the solar power plant will be transferred to BLOC, a financial service provider that will in turn power the Malakal Teaching Hospital (Whittington, 2022).	Energy Peace Partners, International Organization for Migration (IOM), 3Degrees, BLOCK
2	South Sudan Energy Access Project	To increase access to electricity services and strengthen the institutional capacity of the electricity sector in South Sudan (World Bank, 2023b).	The World Bank
3	Terekeka Home System Solar Project	To install standalone solar power systems capable of carrying a load of up to 205 watts per household. The initial design is slated to provide electricity to 60 households in Terekeka town (75km from Juba) in Central Equatoria. The project involves using a prepaid system which is easily available with Zain and MTN mobile networks. It also aims to use portable solar water pumps and solar driers to improve economic activities e.g. fishing in the community.	United States African Development Foundation (USADF), WADS Company LTD
4	VHSS Solar Energy Programme	To implement and deploy solar energy to poor rural citizens by supplying communities with a central solar-powered charging station and portable take-home battery packs for light homes and small businesses.	Village Help for South Sudan (VHSS), Institute of Electrical and Electronics Engineers (IEEE).
5	Solar4Health	To equip health facilities in South Sudan with whole-facility solar power by using a blended finance approach to de-risk long-term solar electricity supply contracts between governments and energy service companies. Energy service companies can thereafter install, operate and maintain high-quality and reliable solar equipment at health facilities.	Bamboo Capital Partners, Crown Agents
6	Solar Sister South Sudan	To centre local women in a rapidly growing clean energy sector by investing in women's enterprises in off-grid communities.	Solar Sister
7	Hybrid off-grid for United Nations Mission in South Sudan	To install solar-hybrid systems in the UN complexes in South Sudan in Juba and Wau.	Scatec Solar, UNIMISS

2.3 Enabling Environment for the Off-Grid Sector

2.3.1 Institutional governing framework

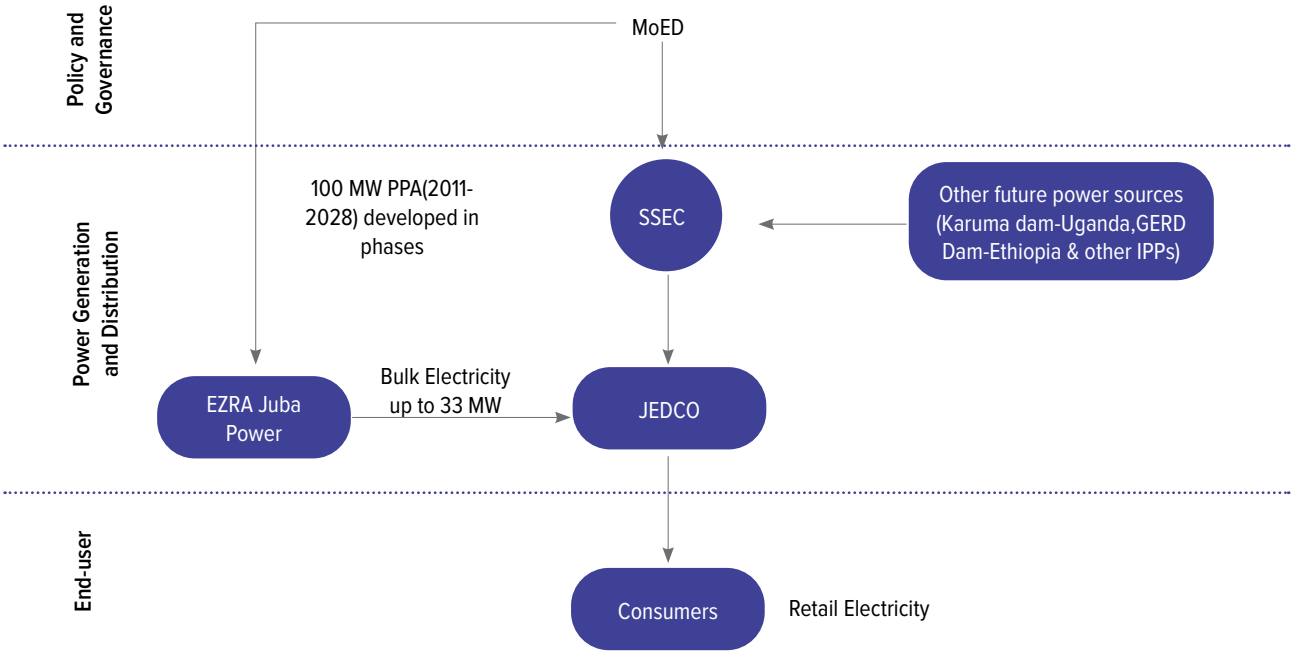
The institutional and regulatory governance of the off-grid energy sector in South Sudan is still nascent. Table 2 below lists the major players participating in the governance of the energy industry and their positions as defined by applicable laws.

Table 2: Institutional and Regulatory Governance Structure of the South Sudan off-grid energy Sector

#	Institution/ Actor	Description
1	Ministry of Energy and Dams	The Ministry of Energy and Dams is the main ministerial body in charge of energy policy and execution. MoED plays a significant role in the overall energy sector. It is the main regulator for the electricity sector in the country (World Bank, 2023b). It is also responsible for the development of renewable energy. Its core mandate is to formulate the necessary legislation and regulations for the electricity supply industry's management, development, and maintenance (Tiitmamer & Anai, 2018). It also oversees compliance with the relevant laws by actors in the sector and identifies potential commercial partners for the development of the energy sector.
2	Ministry of Finance and Economic Planning	It establishes rates for the distribution of electricity in South Sudan in coordination with the Ministry of Energy and Dams. It is also responsible for developing the Finance Act through which amendments to various fiscal policies such as VAT exemptions for the off-grid sector can be made.
3	Ministry of Commerce, Industry, and Investment	It works with the Ministry of Finance and Economic Planning to establish financial guidelines to promote South Sudan's commercial development. It participates in setting import taxes for all products entering South Sudan, including off-grid solar products such as solar panels, solar lanterns, solar lighting systems and solar home systems and appliances.
4	South Sudan Electricity Corporation (SSEC)	The state corporation is designated with the responsibility for the development, operation, and maintenance of electricity infrastructure. It was established on 19 December 2006 through Council of Ministers Order No. 30/2006. According to the Order, it is responsible for electricity generation, transmission, distribution, revenue collection and purchase from independent power producers (IPPs) (Ghandour, 2016). It reports to MoED. Following the post-independence conflict, the role of SSEC in electricity generation and distribution became defunct, with generation facilities being destroyed in the conflict. However, since the resumption of peace, SSEC has been involved in national efforts on electricity generation. Its role as a power utility is expected to intensify as programmes to increase electricity access in South Sudan are implemented.
5	South Sudan Electricity Regulation Authority	It is proposed under the Electricity Bill 2015 as the regulatory entity for the electricity sector in South Sudan. It would function as the energy regulator whose functions would include the creation of regulations. Its role can be distinguished from that of SSEC, which would be limited to electricity generation, transmission and distribution. Under the Bill, SSERA will be responsible for introducing a secure and stable electricity supply, protecting the interests of consumers and other users, encouraging private sector providers in the market, and promoting energy efficiency and renewable energy. These responsibilities would be discharged through review and approval of tariffs, granting of licenses, settlement of disputes, and preventing abuse of power monopoly.
6	Rural Electrification Agency	It is proposed under the Electricity Bill 2015 as the regulatory entity responsible for championing electricity access in rural areas.

FIGURE 6

Institutional set-up for power distribution in South Sudan. [Source: EED Advisory, 2022]



2.3.2 Regulatory framework of the energy sector

Most policies and regulations governing the energy sector in South Sudan are either in draft form or are proposed ideas (Lemi & La Belle, 2020). The two most relevant policies for the off-grid energy sector include the electricity bill and the national electricity policy highlighted below:

i) Electricity Bill 2015

The most relevant regulation in South Sudan's electricity sector, despite it not being passed into law, is the Electricity Bill of 2015. It is yet to be approved by the council of ministers and acquire the status of a law. However, the Bill provides for the establishment of the South Sudan Electricity Regulatory Authority (SSERA), which was envisioned as an independent responsible for licensing and regulation of the generation, transmission, distribution, and supply of electricity within South Sudan (African Development Bank, 2013). According to the Bill, SSEC's role would be developing and operating generation and transmission networks within the country. SSERA, on the other hand, would be entrusted with the responsibilities of

- introducing and maintaining a secure and stable electricity supply;
- protecting consumer interests, particularly concerning tariffs, encouraging private sector participation in the electricity market;
- licensing of actors in the electricity sector;
- monitoring and enforcing performance of regulated entities; and
- encouraging renewable energy promotion (African Development Bank, 2013).

An extensive review of this Bill is required before it is passed into law, given the sector's growth since 2010 and the entrants of players such as JEDCO and other PPP agreements. The Bill, if revised and passed into law, will be the primary national regulation of the electricity sector in the country. The mandates of the different institutions envisioned under the policy might have to change, given the current state of the electricity sector.

In its revision, the Bill should designate a key agency responsible for promulgating sector policies and procedures to comply with the main electricity law. This agency could be the South Sudan Electricity Regulatory Authority (SSERA) envisioned in the 2015 Bill. Additionally, a revision of the Bill should define which institutions would be responsible for regulatory functions, define relationships and scope for PPPs, and define the role of private sector investments in power generation and distribution.

ii) South Sudan National Electricity Policy (SSSNEP), 2007

The South Sudan National Electricity Policy (SSSNEP) of 2007 outlines the framework for the development of the electricity supply industry (ESI), including strategies for Public-Private Partnerships (PPPs). It recognises the need to create oversight for investor confidence to attract private investors to contribute to the development of the electricity sector (African Development Bank, 2013). However, like the Electricity Bill, a review of the South Sudan National Electricity Policy is required, which reflects the realities of the electricity sector in Sudan and its visions for the future growth of the sector. This would include strategies for promoting renewable energy to increase the country's electricity generation mix since South Sudan has vast renewable energy resource potential in hydropower, wind, solar, geothermal and biomass.

An assessment of the adequacy of these policies and regulations to support the off-grid sector indicates weak frameworks to support both the stand-alone systems and mini-grids, as shown in Figure 7 below.

In comparison with Kenya, which has a highly scored framework for mini grids and standalone systems, some of the key enabling elements still lacking include:

i) A national programme to promote adoption of stand-alone solar systems.

ii) An indication of subsidies or duty exemptions to promote the off-grid sector.

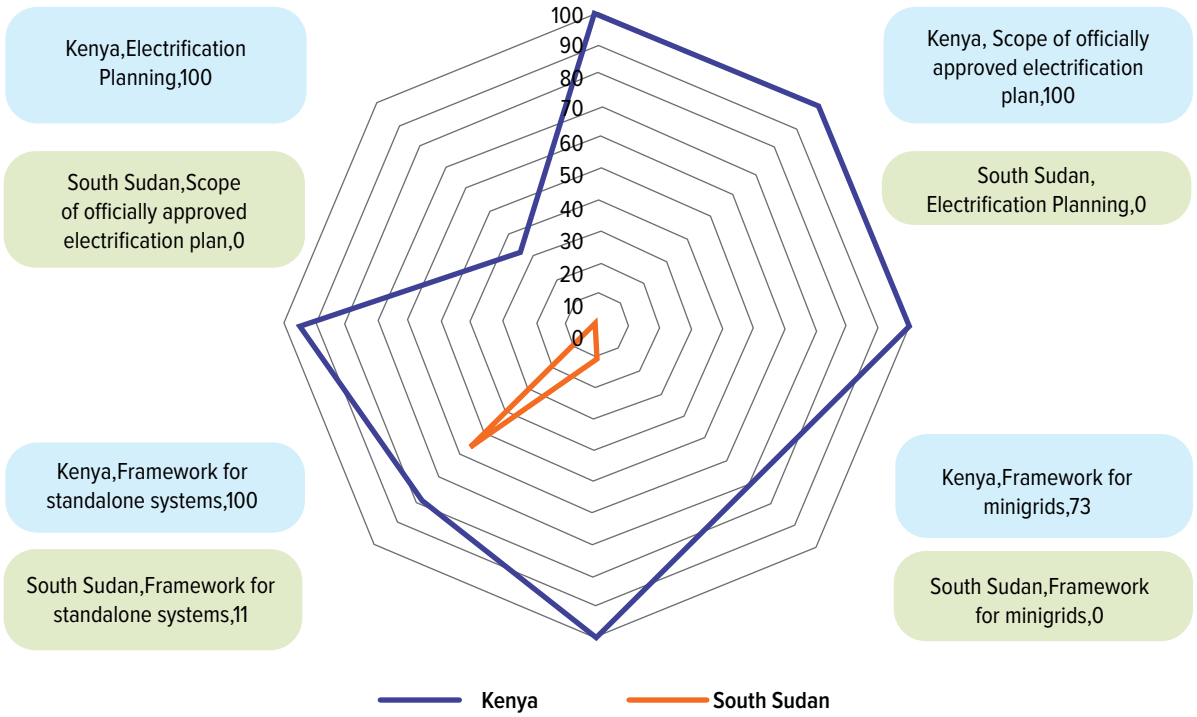
iii) No legal limit on the prices of standalone solar home system retailers and service providers.

iv) Formal adoption of international solar product quality standards and test methods.

More detail on strengthening the regulatory framework is provided in Chapter 6.

FIGURE 7

Comparison of Kenya's and South Sudan's Score on Electricity Access Indicators from World Bank's Regulatory Indicators for Sustainable Energy (RISE) Framework [Source: ESMAP]



3. Demand Side Characterization of the Off-Grid Market

The national electricity access rate is low at

5.4%

a slight increase from previous reports that quoted an access rate of **4.2%** in 2017

3.1 Household Assessment

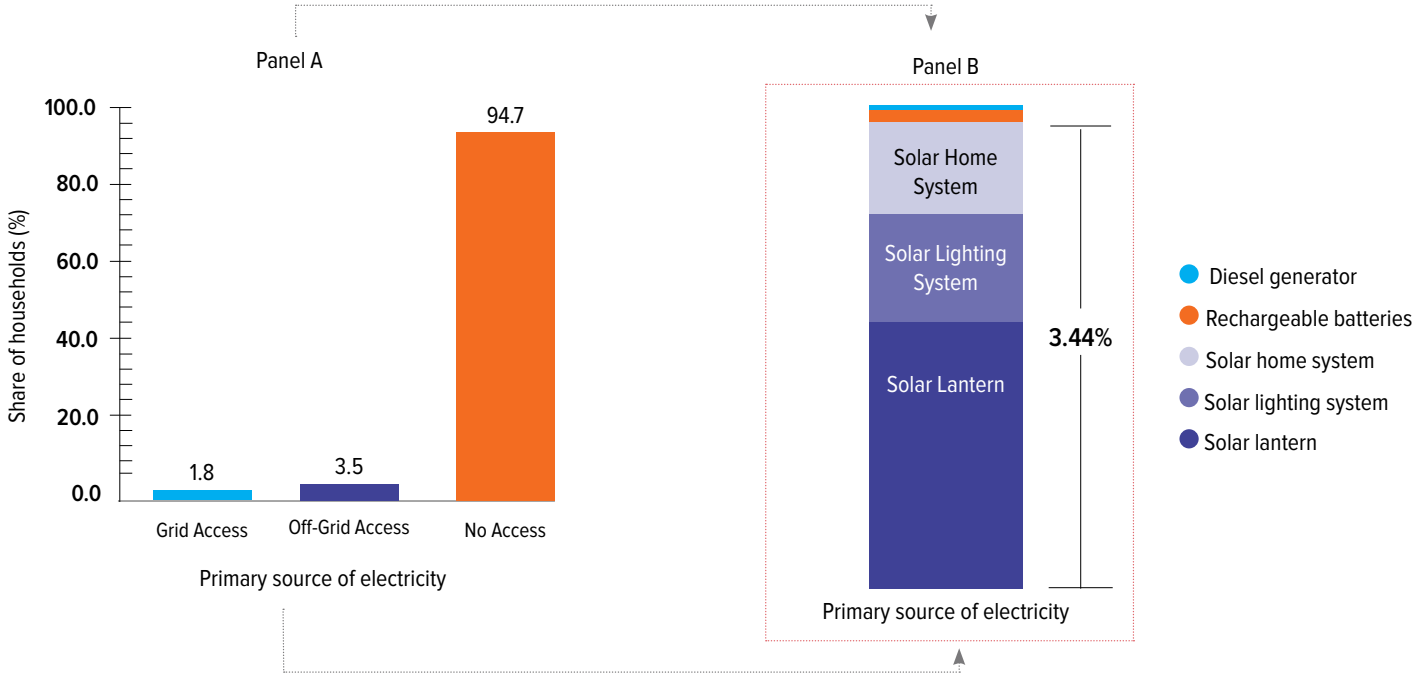
As detailed in chapter 1, section 1.3, the demand side assessment in subsequent sections in chapter 3 are insights drawn from the survey of 1,261 households across the 10 States in Sudan. The analysis outlines the current off-grid energy demand for domestic and institutional consumers. The survey findings are supplemented by qualitative analysis from 10 Focus Group Discussions across the States.

3.1.1 Access to Grid Electricity and Off-Grid Technologies

According to this survey, the national electricity access rate is low at 5.4%, a slight increase from previous reports that quoted an access rate of 4.2% in 2017 (Ministry of Health, 2017). Most households, 94.7%, have no access to an electricity source; 1.78% are connected to the JEDCO mini-grid; and 3.53% use off-grid technologies (SL, SLS, SHS and rechargeable batteries) (Figure 8 – panel A).

FIGURE 8

Access to electricity and off-grid technology, nationwide

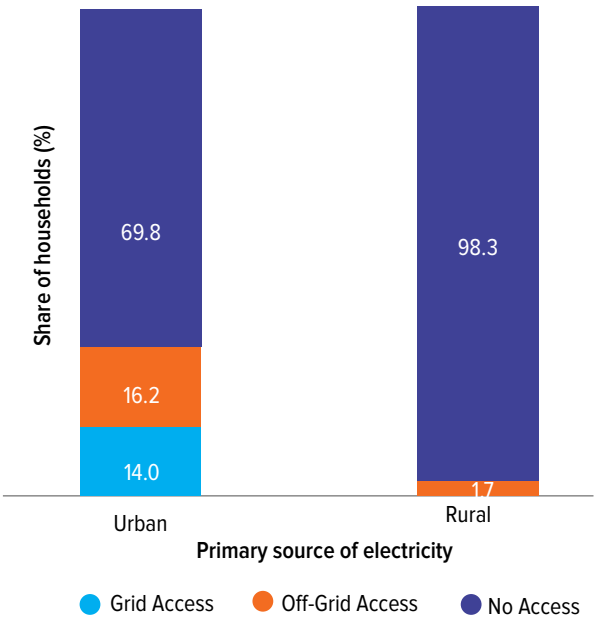


Urban households have a far higher rate of electricity access than rural households, but across both urban and rural households, solar PV is the most popular off-grid source of electricity. Although most rural households, 98.3%, have no access to electricity, 1.7% report access through off-grid solar products, of which 1.5% are solar lanterns, and 0.2% are solar lighting systems.

About 70% of households in urban areas have no access to electricity, while the remaining 30.2% have access through micro and mini-grids (14.0%) and off-grid technologies (16.2%) (Figure 9). For the solar products in urban areas, 4.98% are solar lanterns, 6.4% use solar lighting systems, and 3.8% are solar home systems. This can be attributed to the concentrated off-grid solar dealers and electronic shops in urban areas where there is more cash flow from businesses and employment opportunities by development and non-governmental organisations.

FIGURE 9

Electricity access and off-grid technology in urban and rural areas



Source: Freepik

Off-grid technologies provide access to

67.9%

of the households that reported having a source of electricity,

3.1.2 Demand for Off-Grid Technologies

Off-grid technologies provide access to 67.9% of the households that reported having a source of electricity, underscoring the significant role that these technologies play in electrifying households. As previously described, these technologies are primarily off-grid solar products. The 2022 Off-Grid Market Trends Report classifies the South Sudanese off-grid solar market as nascent due to i) the large electricity access gap (from the survey, 90% of households) and the relatively low sales volumes realised in the market – the Semi-Annual Sales Records by GOGLA (O. Reynolds, personal communication, March 22, 2023) indicate cumulative sales units of 142,821 from 2016 – 2021 by affiliate brands[2] .

Although the off-grid solar market is still nascent, the popularity of these products among off-grid households indicates the importance of understanding the types of solar products households use, availability of the products, affordability, consumer considerations for purchase, and consumer awareness of products.

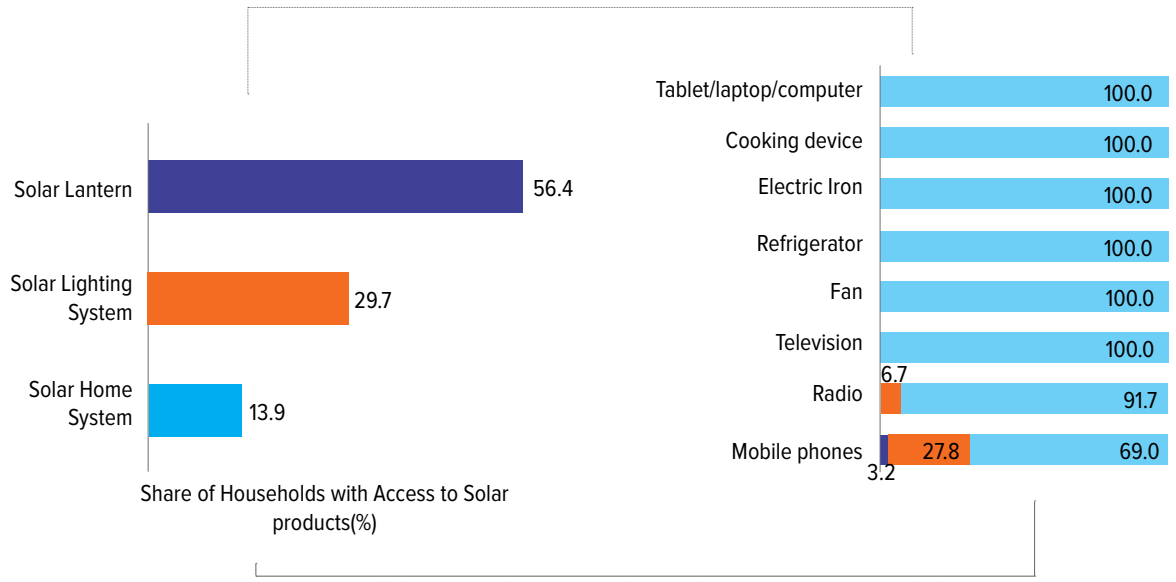
Types and use of Products

Out of the 3.4% of households with access to off-grid solar products, 56.4% are solar lanterns, 29.7.% are solar lighting systems, and 14% are solar home systems.

Rural households primarily purchase lanterns (89.0%) and solar lighting systems (11%). In comparison, urban households purchase solar lighting systems (43.7%) and solar home systems (24.3%), recording fewer solar lantern purchases (32%). These products are commonly used to power mobile phones, televisions, radios, and fans, as shown in Figure 9. Based on the median, these solar products were reported to power household appliances for 5 hours during the day and 2 hours at night. Hence, most households with solar products can be characterised as Tier 1 (at least 4 hours during the day and 1 hour in the evening) of the multi-tier framework (MTF) classification (African Development Bank, 2013).

FIGURE 10

Appliances powered by the Solar Products



2 Sales data by manufacturers affiliated to GOGLA

Availability of off-grid solar technologies

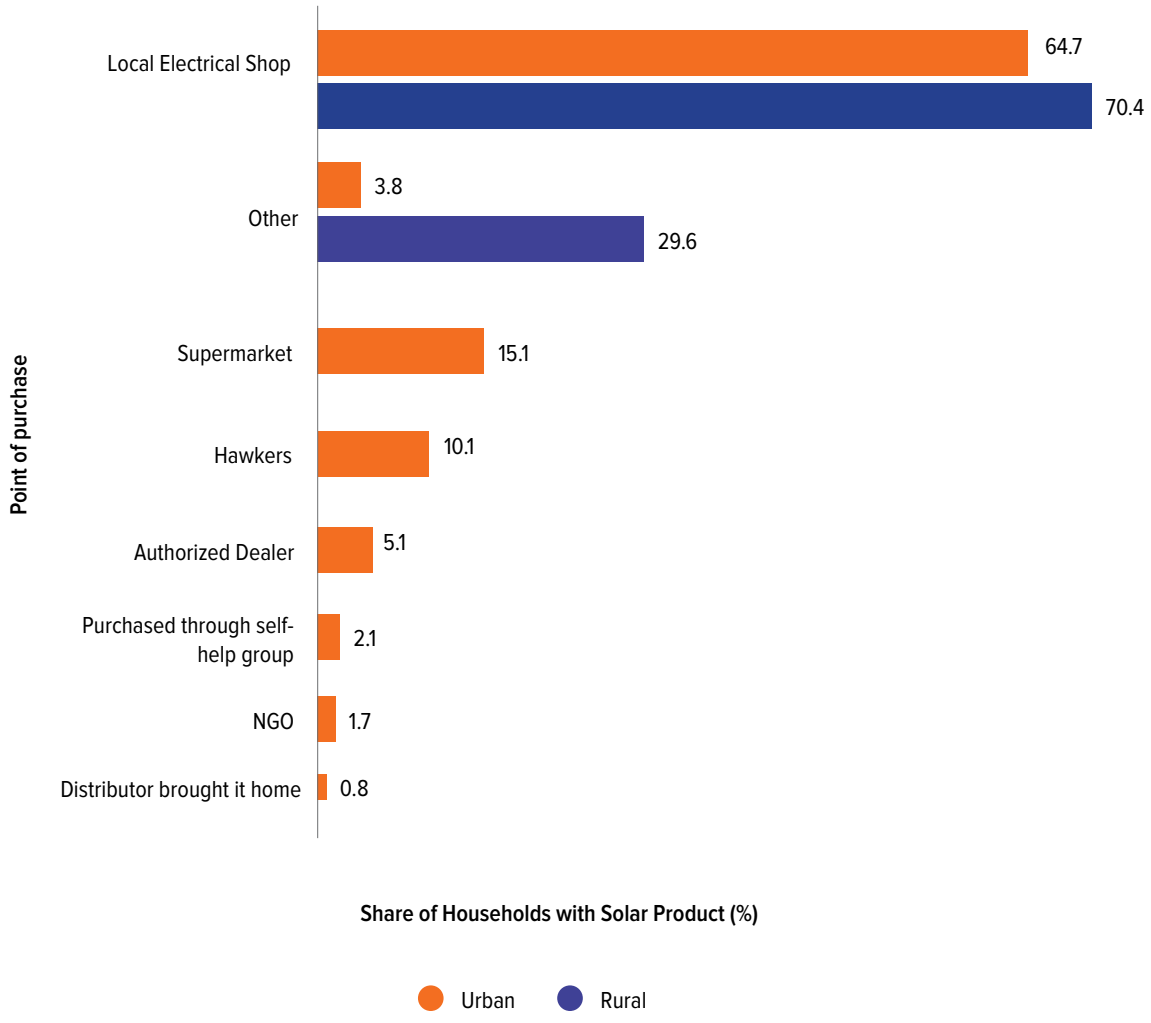
Availability is defined through the number of distribution channels and distance from the point of purchase. The availability of off-grid technologies is limited, especially for rural households with few points of purchase and who have to travel long distances to purchase off-grid solar products.

The third-party model is the leading distribution channel by manufacturers, primarily through local electronic shops (67.1%), supermarkets (8.6%) and hawkers (5.8%).

Rural households indicate having only two points of purchase, the local electronic shop (70.4%) or other channels (29.6%), e.g., purchases made outside the country or purchased through a relative. In comparison, urban households have more options for points of purchase, including electronic shops (64.7%), supermarkets (15.1%), hawkers (10.1%) and authorised dealers (5.1%), as shown in Figure 11 below. Rural households also travel longer distances, about 10.3 hours, to their point of purchase compared to 2.3 hours for urban households.

FIGURE 11

Availability of off-grid solar technologies



Key aftersales services through the provision of a warranty are lacking in the market. Only 21.1% of households with solar devices received a warranty upon purchase, all were within urban areas. No rural household reported receiving a warranty. Access to aftersales support services is crucial to the uptake of off-grid solar products and to address customer's concerns over the quality of solar products purchased.

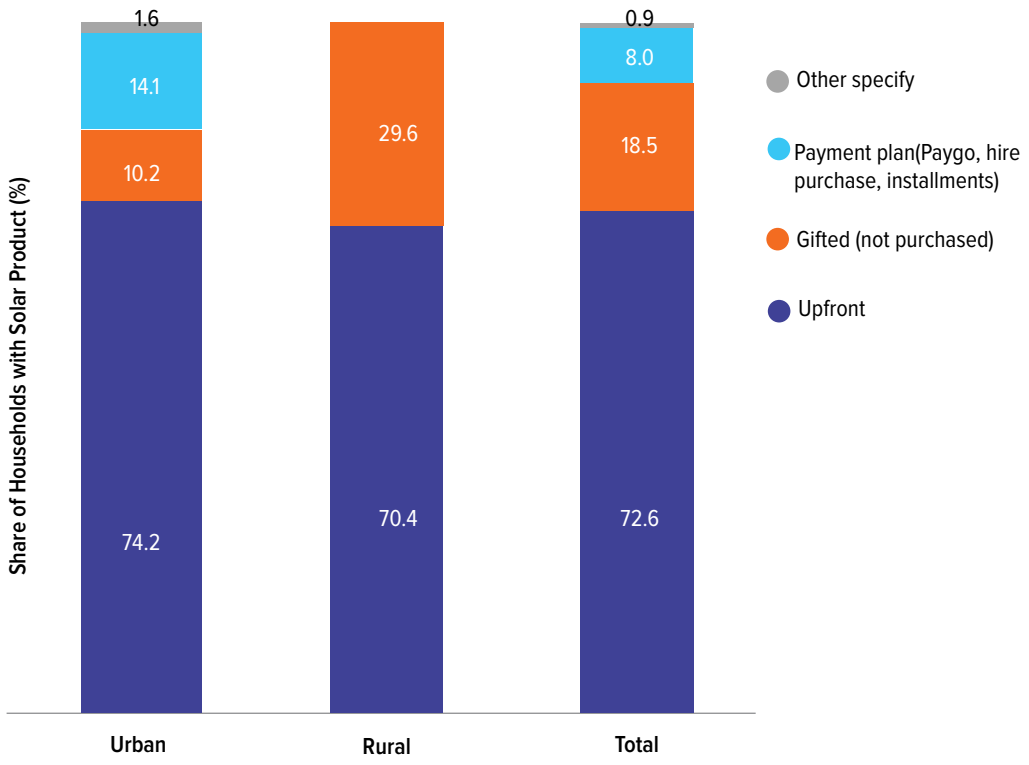
Affordability

The affordability of solar products for households is examined through the purchasing cost and payment flexibility.

Off-grid solar users have very limited financing options to purchase standalone solar products. Less than 8.1% purchased their solar products through consumer financing (e.g., payment under instalments or financing through informal financial institutions), while 73.4 % purchased their solar products by paying upfront, and 18.5 % received their devices as a gift from family, relatives or NGO, respectively. According to the survey (Figure 12), no rural households with a standalone solar product had access to any payment options/consumer financing, while slightly more than 15% of urban households had access to the payment/ financing options.

FIGURE 12

Payment methods for solar products in urban and rural households

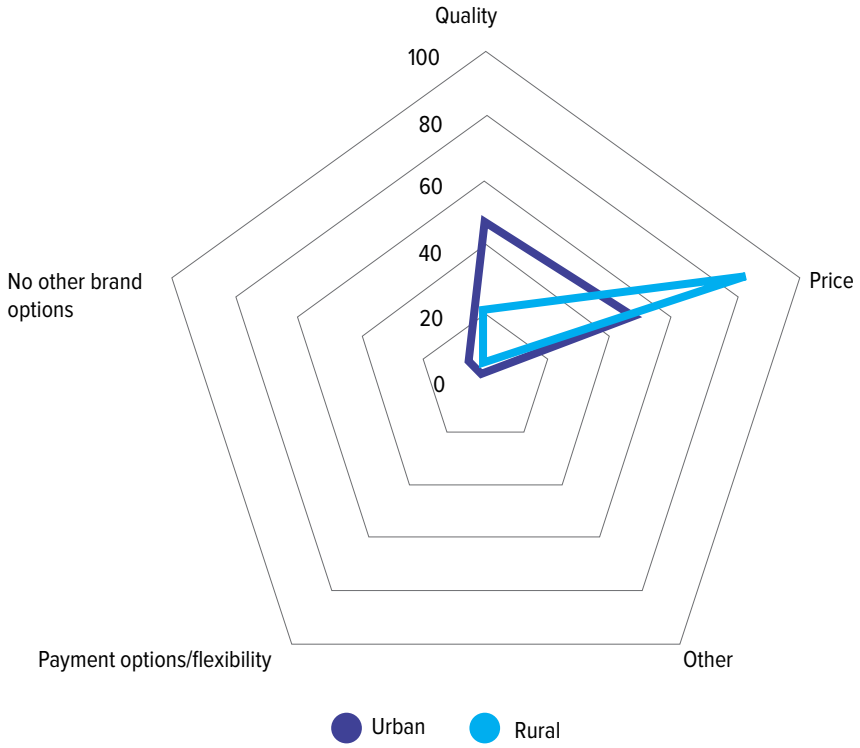


Despite the limited financing options described above, most of the population (using off-grid technologies) purchased SHS with which they can power additional appliances, including television, refrigerators, and fans, among other appliances. Solar lanterns, on average, are purchased at USD 18.50, solar lighting products at USD 71.6 and solar home systems at USD 261.79.

Since rural households are poorer and have fewer financing options than urban households, their main consideration when buying an off-grid solar product is price. However, urban households consider the quality of standalone solar products and price equally important, as presented in Figure 13 below.

FIGURE 13

Consumer Considerations for the Purchase of a Solar Product



Perceived Quality

Most respondents are not satisfied with the quality of their solar products, as measured by the quality of power and device functionality. Only 22% of the respondents are satisfied with the quality of power. This is because the power supply cannot power all the household appliances (39%), and the power runs out at night (28%). About 16% of the households also reported that their devices had stopped functioning.

BOX 1

Consumer Awareness of Solar Products

Interventions to increase consumer awareness and education on solar products and their benefits as well as the importance of buying quality products is required to increase uptake. Consumer awareness of solar products in the South Sudan market is low. This is observed by considering both the households with and without access to solar products:

i) **95.5%** of households with access to solar products learnt about their devices from friends and families (Advertisements through media accounted for less than 2%).

ii) **82.8%** of all the households surveyed have never heard of any of the ten solar product brand names witnessed in the market indicating a need to educate consumers on the availability of products.

iii) **8.41%** of the households without access to solar products do not know what a standalone solar product is and what benefits they could expect.

3.1.3 Expanding Household Access to Electricity

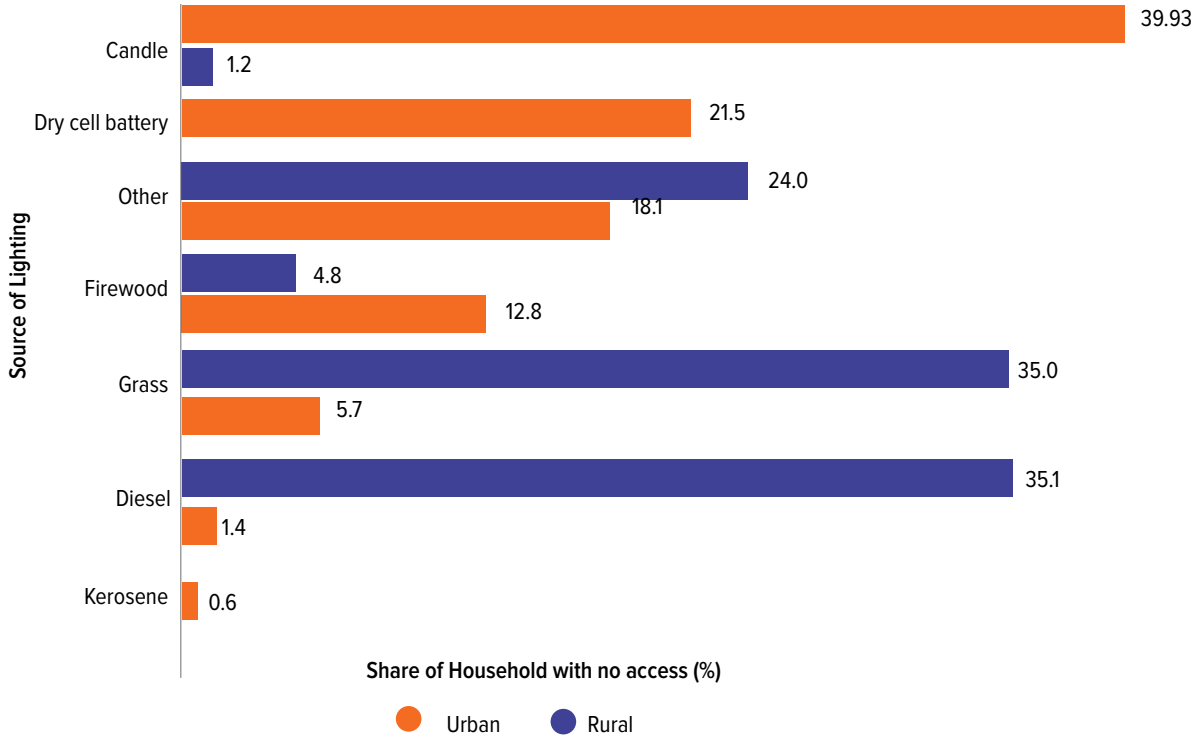
Current sources of lighting for households without access to electricity

Nationally, at least nine in every ten households have no access to electricity. Majority of these households report using three main sources for lighting, firewood (32.0%), grass (31.1%) and dry cell batteries (23.6%). However, disaggregating this grouping into urban and rural populations reveals that urban households primarily use candles (39.9%), while rural households mainly use grass (35.1%) or firewood (35.0) as their main source of lighting (Figure 14). Kerosene and Diesel are only used in urban areas by 2% of the population.

Nationally, at least
9/10
households have no access to electricity

FIGURE 14

Main Source of Lighting for Households with No Access to Electricity, Urban and Rural Populations. The category 'other' is primarily lighters and phones.



On average, households spend about USD 2.8 monthly on lighting nationwide. However, the average monthly spend in urban households is higher at USD 6.1 compared to USD 2.3 for rural households. When disaggregated according to the fuel types, respondents reported that diesel was the most expensive fuel, with those using it spending about USD 38 per month, followed by kerosene (USD 6 per month) and dry battery cells (USD 4), firewood (USD 0.7), and candles (USD 3).

Improving access for households without access to electricity requires understanding the core barriers. For purposes of the study, the barriers are reviewed with reference to

i) access to the grid and
ii) access to off-grid technologies, specifically solar products.

The analysis also evaluates the willingness to pay for the grid and off-grid technologies.

Barriers to Gaining a Grid Connection

The main barrier preventing these no-access households from gaining a grid connection is the lack of grid infrastructure in rural and urban areas. Households (urban 65.2% and rural 74.3%) report that the grid is too far from their dwellings or entirely unavailable.

Willingness to Pay for a Grid Connection

Besides distance from a grid, the connectivity cost is the key demand-side barrier to grid access, especially for rural households. Whereas the core barriers of lack of grid infrastructure and service reliability can be tackled through the supply side, affordability was further explored through the willingness to pay on the demand side.

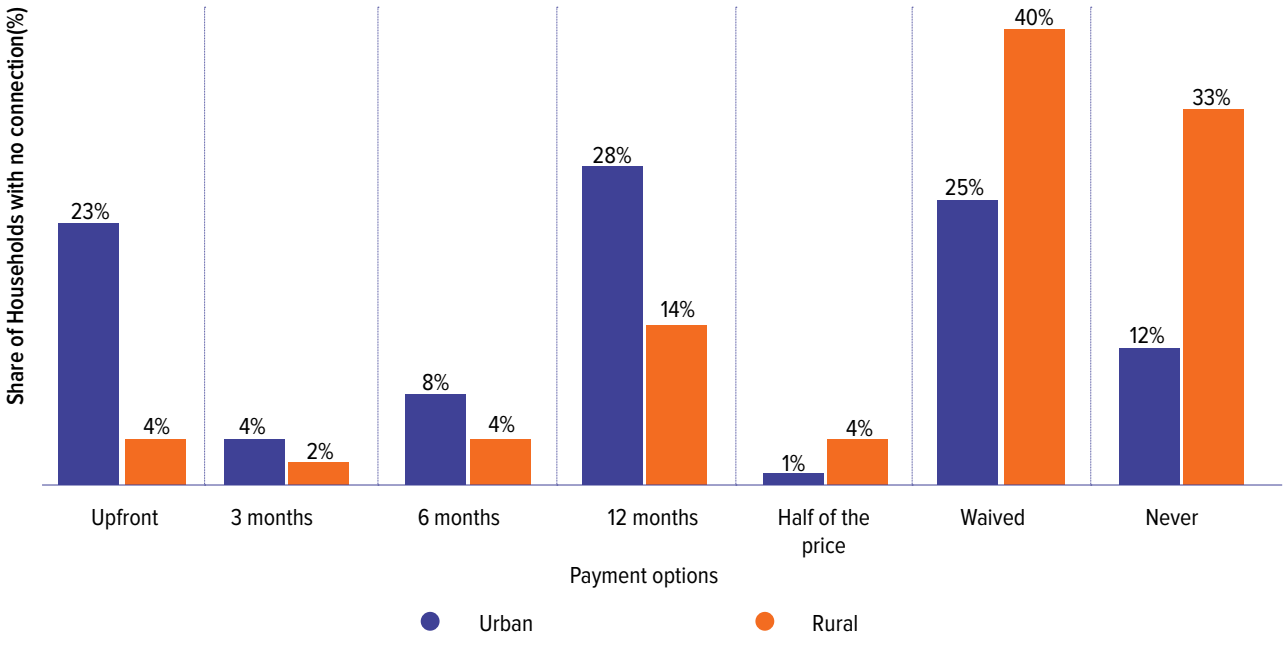
This study assessed willingness to pay for a grid connection by introducing payment flexibility for households with no access to the grid (rural and urban households). With a grid connection cost of SSP 65,000 (USD 108), the respondents were presented with seven payment options as follows:

i) One instalment: Upfront cost of USD 108,
ii) Three monthly instalments: of USD 36
iii) Six monthly instalments: of USD 18
iv) Twelve monthly instalments: of USD 9,
v) Subsidized fee (50% of full connection cost): USD 54
vi) Waived connection fees except for wiring
vii) Never paying for the connection

As presented in Figure 15, only 4% of rural households are willing to pay upfront for a grid connection, compared to 23% of urban households.

With consumer financing, there's a potential to increase uptake for the national grid, especially for the urban population. With the introduction of consumer financing, the proportion of urban households willing to pay the full connection cost increased from 23% (households willing to pay upfront) to 63% (households willing to pay upfront or over time). Noteworthy is that 40% of the urban households would be willing to pay for the full connection cost with financing, while only 26% would require a 50% subsidy or a waived connection fee. An additional 24% of rural households would be willing to pay for a connection with consumer financing. For households willing to pay for a connection, a higher percentage of the urban (28%) and rural (14%) preferred to pay over 12 months. However, 25% of urban and 40% of rural households still indicated that they would not be willing to pay the connection cost, even with financing options, by selecting the waived fee option.

FIGURE 15
Willingness to pay for grid connection



Even with a waived connection fee, the internal wiring costs remain a barrier to access. The study inquired why respondents were unwilling to get a grid connection under any payment plan, even with a waived connection fee option (fully subsidized connection fee). The main reason was that respondents (urban: 62%, rural: 71%) could not afford the wiring costs (Figure 15 below). The other reasons were

i) the perception by respondents (urban: 30%, rural: 9%) that the monthly consumption fees were too expensive, and

ii) respondents believed that they did not need electricity (urban: 3%, rural: 6%) as presented in Figure 16 below.

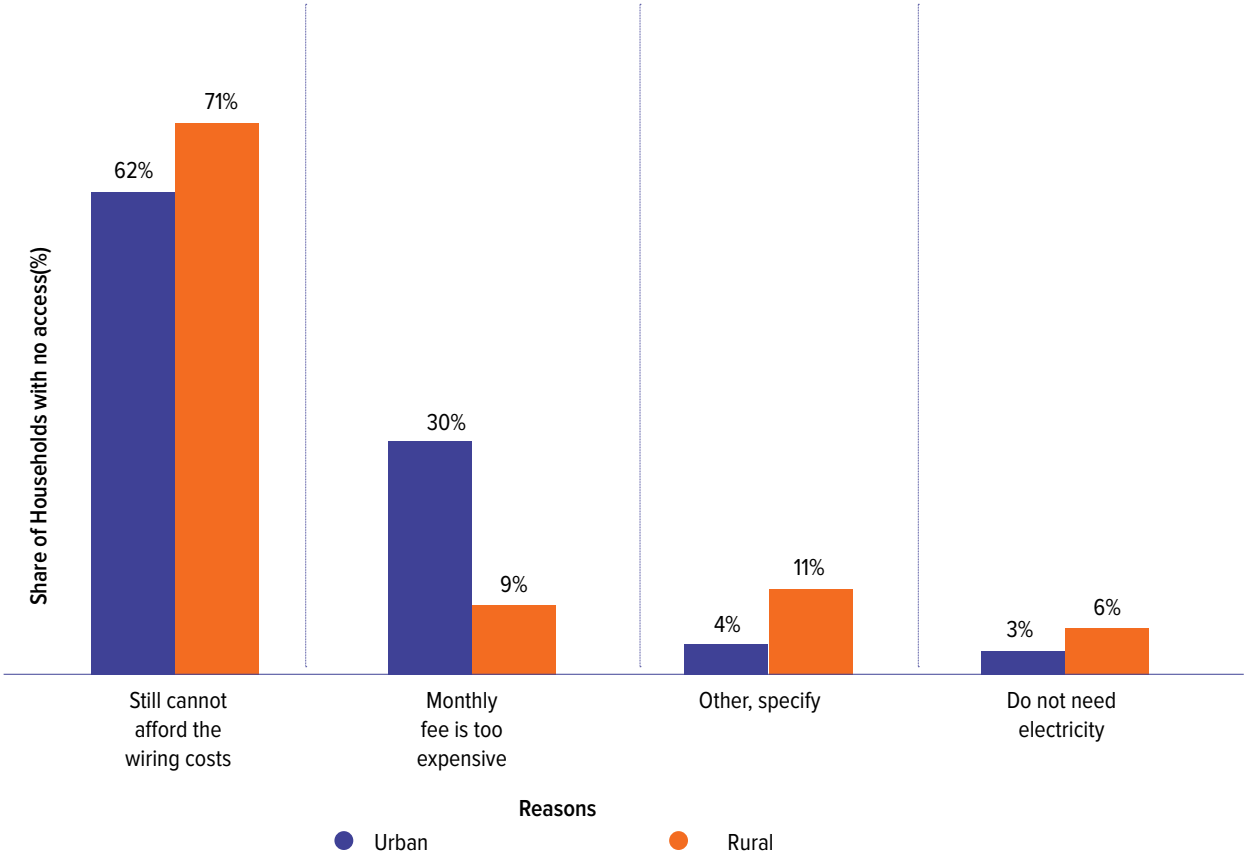
Table with

urban	rural
62%	71%

of respondents were unwilling to get a grid connection even with a waived connection fee because they could not afford the wiring costs.

FIGURE 16

Reasons for unwillingness to pay a connection fee or accept a waived connection fee

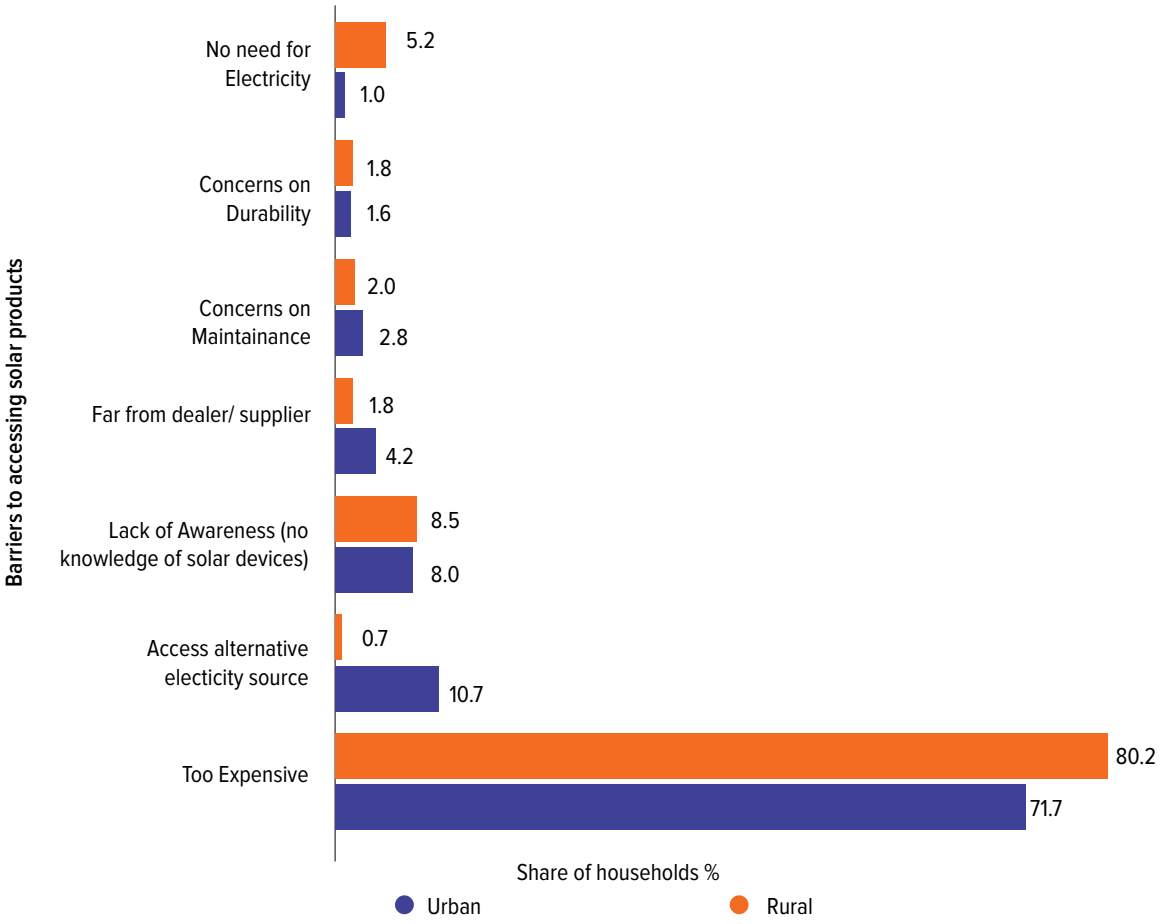


Barriers to accessing an Off-Grid Solar Product

The main barrier to accessing off-grid solar products is the cost of the devices. At least 7 in every 10 households that do not own a solar device for the rural and urban populous perceive solutions as too expensive (Figure 17). The second barrier is the lack of awareness, where at least 8% of both urban and rural populations do not know what a solar device is.

FIGURE 17

Barriers to Accessing Solar products for Households that do not own the product



Willingness to pay for a Solar Product

Respondents were asked if they would be willing to pay SSP 65,000 (USD 108) for a solar lighting system through different payment options. The options included

i) paying the whole amount upfront,

ii) 6 months' instalments,

iii) 12 months' instalments,

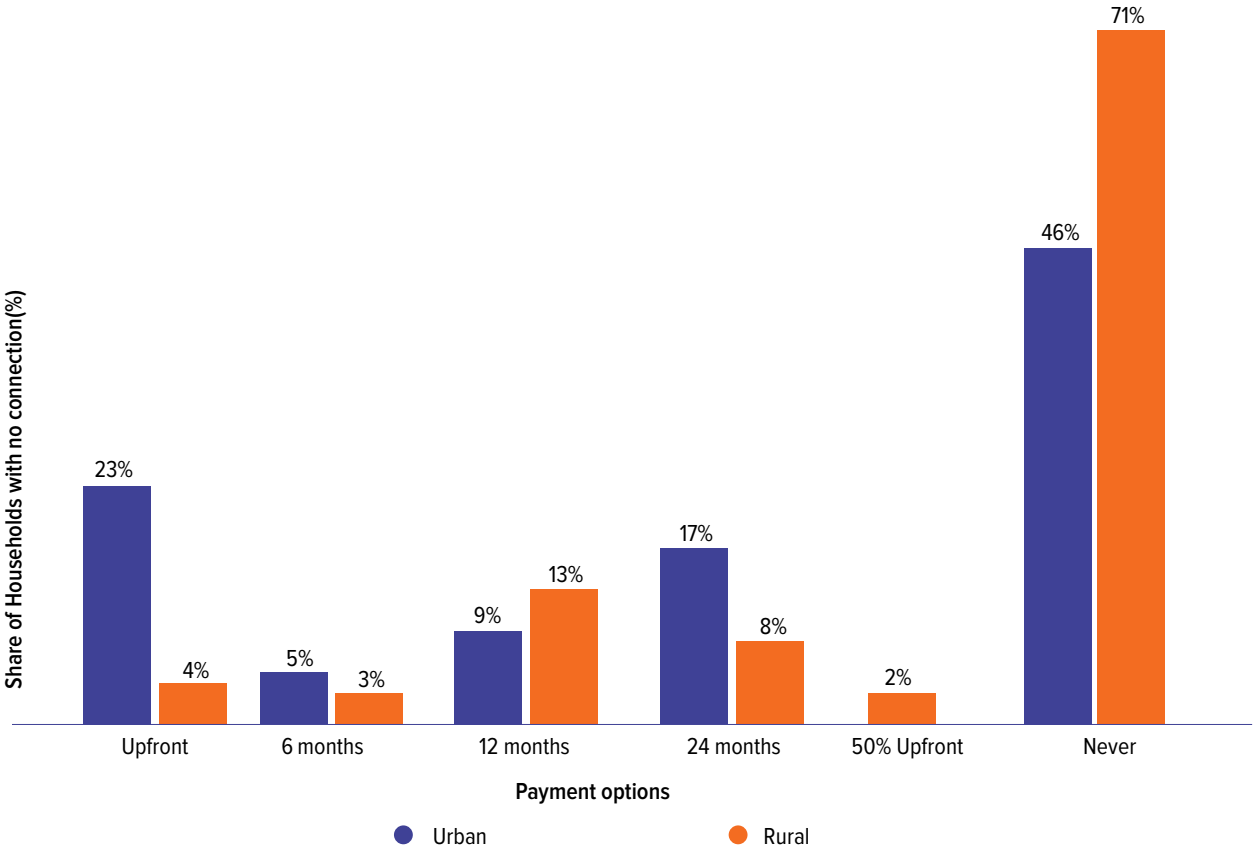
iv) 24-month instalments, and

v) half the price upfront.

With consumer financing, there's potential to increase the adoption of solar products. Less than a quarter and 5% of unelectrified urban and rural households are willing to pay a fully upfront cost to purchase a solar product. With the consumer financing, additional 31% and 24% of unelectrified urban and rural households will be able to purchase a solar product. (Figure 18 below). More than 70% of unelectrified rural households mostly won't accept any offer due to the affordability constraints.

FIGURE 18

Willingness to pay for a solar lighting system



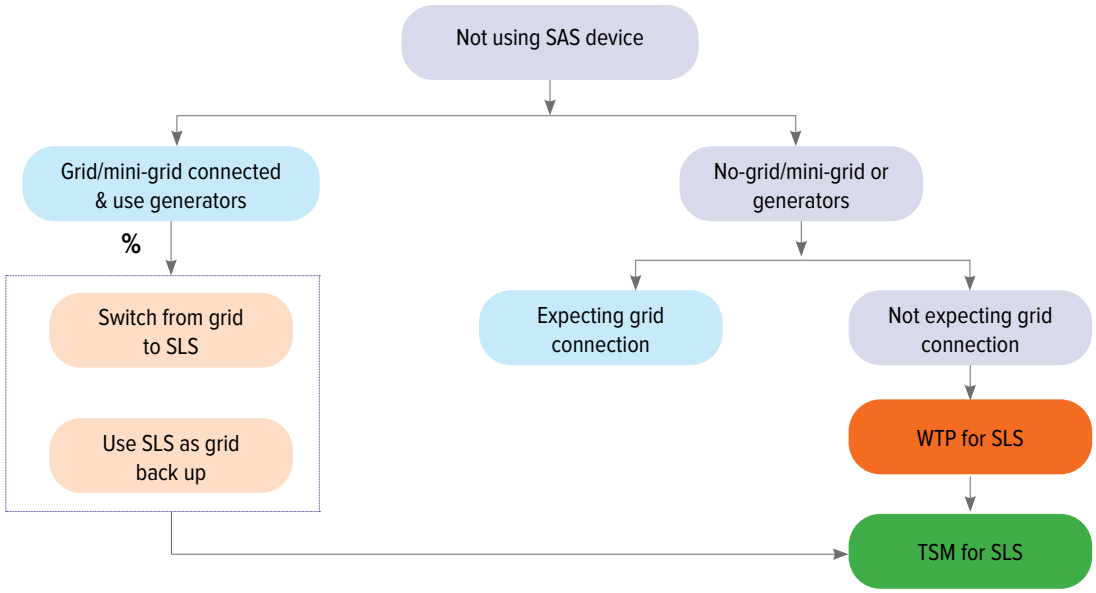
Source: Shutterstock

3.1.4 Potential Market Size for Solar Products:

The total addressable market (TAM) and serviceable market (TSM) represent i) the total revenue opportunity or total market demand of solar products for households without electricity (not connected to the grid, mini-grid or a solar product) and ii) the total revenue opportunity for the market segment that can be realistically served by solar products, respectively. The approach applied is illustrated in Figure 19 below.

The total potential consumer base is about **90%** of the population.

FIGURE 19
Approach TAM and TSM



Assumptions

- The potential customers (households) for solar lighting systems (SLS) consist of households with no access to electricity through standalone solar (SAS), grid/mini-grid or generator sets and grid/mini-grid households that use SLS as a back-up source of electricity.
- The cost of a solar lighting system is USD108.

The fraction of households with no access to electricity either through a grid, generator or a standalone solar device was 85.7% in urban and 98.3% in rural areas translating to 244,274 and 1,120,620 households. Households connected to the grid/mini-grid were 36,138 (all in urban areas), while those expecting a grid connection are 21.6% in urban areas translating to 61,589 households. We calculate the addressable and serviceable market using the following formulas (CFI, 2023).

- Addressable market (USD)=Total number of potential customers (households)* value of the SLS device
- Serviceable market (USD)=Potential customers for the SLS e*value of the SLS*compositefraction of HH WTP for SLS device

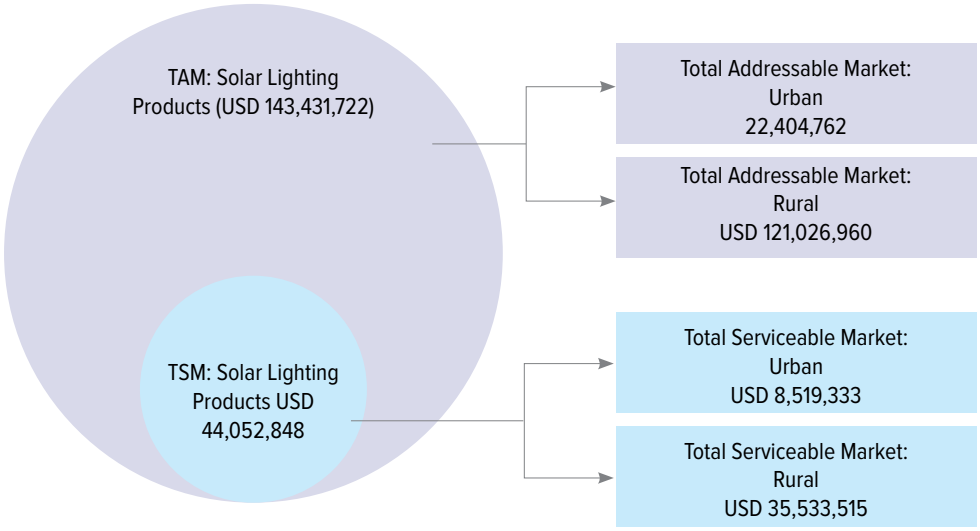
Where: the composite (upfront, 50% upfront, 6 months, 12 months, 24 months) fraction of households willing to pay for a solar lighting system (SLS) was 54.1% in urban areas and 29.4% in rural areas.

Total Addressable and Serviceable Market for Solar Lighting Products

Based on the solar access rates and willingness to pay assessments, the total addressable market for solar products in South Sudan is USD 143,431,722, and the total serviceable market is USD 44,052,848. The total potential consumer base is 1,226,483 households, about 90% of the population.

FIGURE 20

Total Addressable Market (TAM) and Total Serviceable Market (TSM) for Solar Lighting Products for an estimated market size of 1,226,483 units sold.



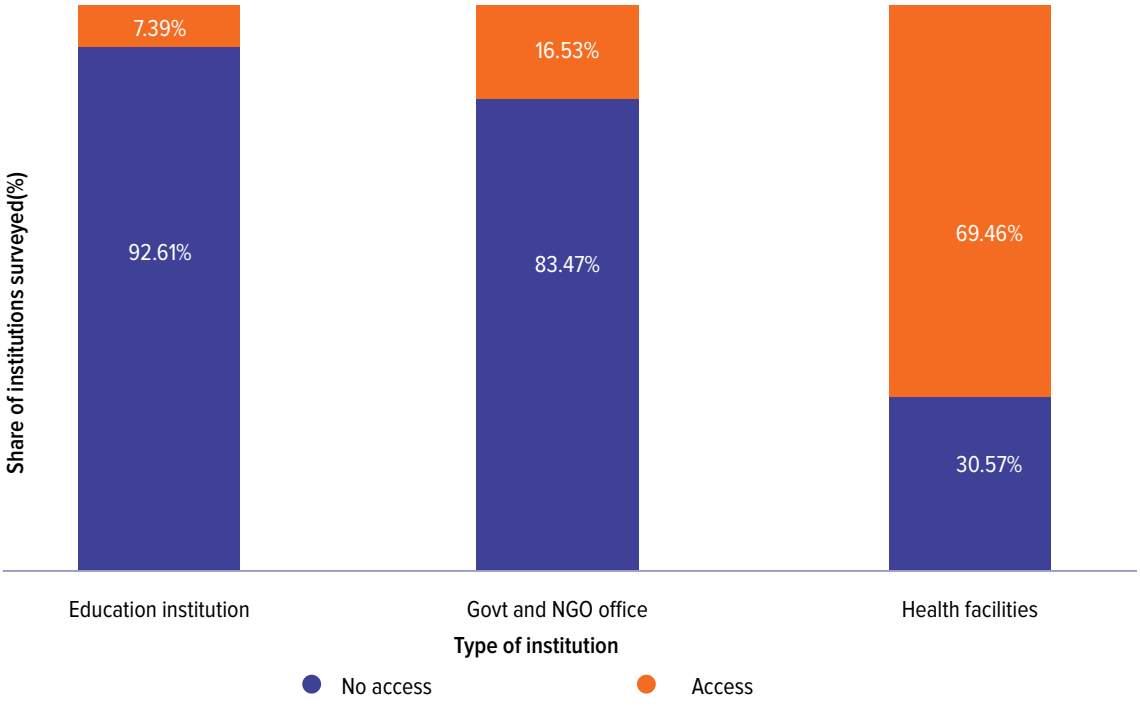
3.2 Institutional Access to Off-Grid Technologies

In addition to households, this study examined energy demand for three types of institutions that provide important services in South Sudan, 1) health, 2) educational, and 3) government and NGO offices. The government offices surveyed were local administration offices and police stations.

Of 281 total institutions surveyed across the ten states in South Sudan, educational institutions had the lowest electricity access rate at 7.4% (n = 74), followed by government and NGO offices at 16.5% (n = 72) and health facilities at 69.5%% (n = 73) as shown in Figure 21 below.

FIGURE 21

Electricity Access Rate across institutions (n = 281)



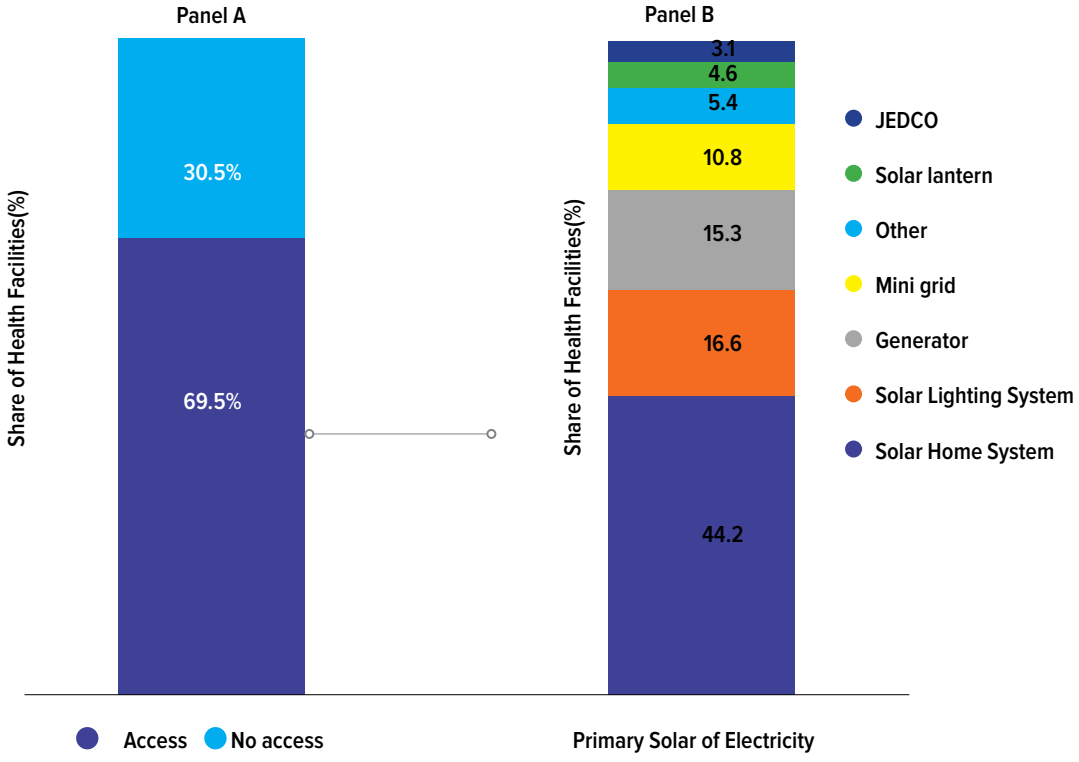
3.2.1 Health Institutions

Access to electricity

About 30% of South Sudan health institutions do not have access to electricity. However, there were disparities where 15.0% of health institutions in urban areas lacked access to electricity compared to 33.2% of health institutions in rural areas reported lacking electricity access. Most (69.5%) healthcare institutions with access to electricity relied on off-grid solar solutions as their primary source of electricity, including solar home systems (44% of total healthcare institutions), followed by solar lighting systems (17%) as shown in Figure 22 below.

FIGURE 22

Primary source of electricity for healthcare institutions



BOX 2

Electricity access for healthcare institutions in Juba

In the Juba area, all health facilities reported having access to electricity, with 89% connected to the JEDCO mini-grid as the primary source followed by generators (9%) and solar home systems (3%), shown in Figure 23 below. Most (75%) of the facilities using solar devices reported to have fully paid for them, while 25% were partially sponsored. The mean annual expenditure on electricity among facilities connected to the JEDCO or a mini-grid was SSP 41,1047 (≈USD 685) and SSP 629,444. (≈USD1,049).

FIGURE 23

Primary source of electricity for health facilities in Juba

Of the health facilities without access to electricity, 61% of urban healthcare facilities and 77% of rural healthcare facilities reported a lack of an alternative source for primary lighting. The lack of access to a primary lighting source limits the operation hours of the health facility and the provision of health services at night-time. The health facilities in this study reported operating for an average of 16.66 hours a day, with health facilities in rural areas operating for an average of 16.5 hours per day compared to 17.21 hours per day in urban areas.

The main barrier to accessing solar devices for lighting is affordability. Most (78.25%) healthcare facilities without an off-grid solar device reported that it was too expensive to acquire them. About half (51%) of facilities that used off-grid solar devices reported having acquired them at no cost through donations, while 24% received partial sponsorship and 25% fully paid for the devices. Health facilities reported spending an average of SSP 181,935.51 (≈USD 303) on electricity from a grid or mini-grid in a month and SSP199,727.61 (≈USD333) on generator fuel.

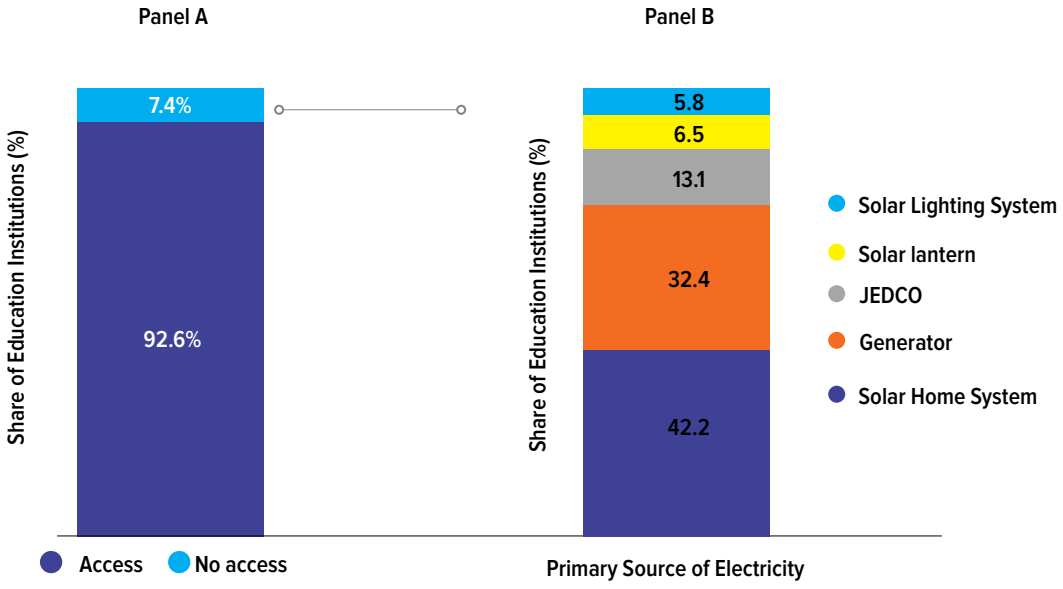
3.2.2 Educational institution

Access to electricity

Most (92.6 %) of educational facilities reported lacking access to electricity, with those that had access to electricity mainly relying on solar home systems (42.2%) and generators (32.4%), as shown in Figure 24 below. Educational institutions using generators reported using them on an average of 25 days a month.

FIGURE 24

Primary source of electricity for education institutions with access to electricity



Most (81.1%) educational institutions reported that the main reason they did not own an off-grid solar device was that they are expensive to purchase, while 16.7% reported that the devices were not available in the market. Most (58.1%) of the institutions that owned and used off-grid solar devices reported purchasing them without external support; 34% were partially sponsored, while 7.9% got them for free.

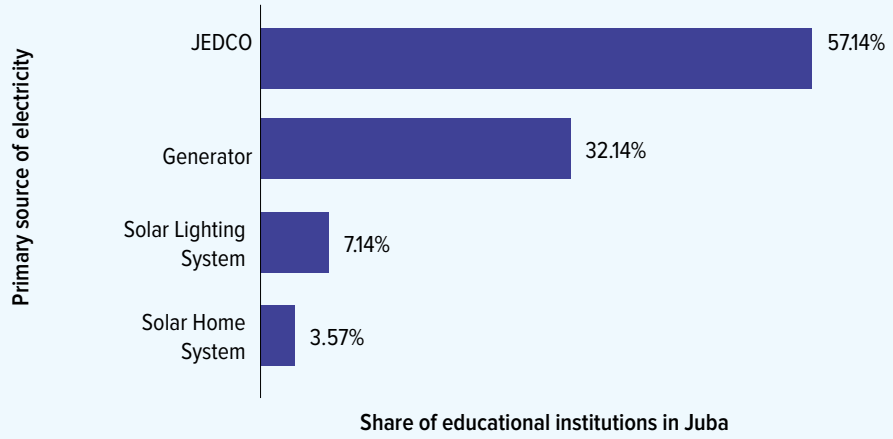
BOX 3

Electricity access for educational institutions in Juba

Most (73.68%) educational institutions in Juba reported having access to electricity, with JEDCO (57.1%) being the main electricity source, followed by generators (32.1%), as shown in Figure 25 below. Additionally, educational institutions with electricity in Juba reported spending an average of SSP80769 (≈USD135) on electricity monthly. Institutions that operated a generator reported using them at an average of 21 days per month. All the educational using off-grid solar devices institutions in Juba reported purchasing them without sponsorship. Most (55.3%) of those without off-grid solar devices reported that they were expensive, while 18.4% weren't aware that off-grid solar devices could power their institutions, and 7.9% reported that the devices were not available.

FIGURE 25

Primary sources of electricity for educational institutions in Juba



3.2.3 Government and NGO offices

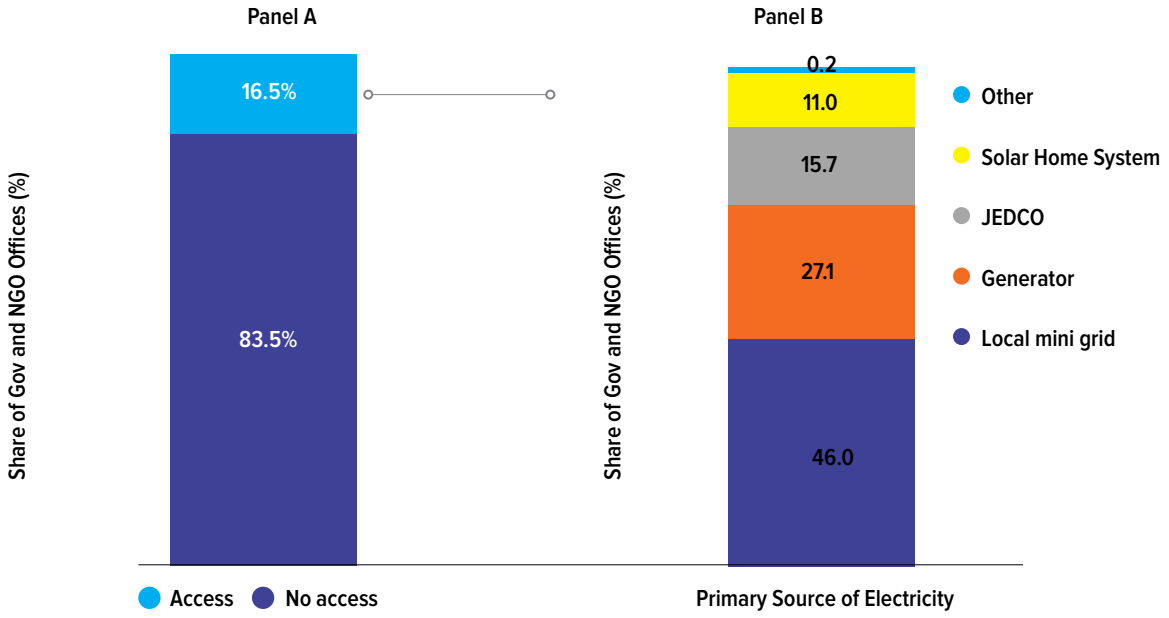
There are several Non-Governmental Organisations (NGOs) working in South Sudan, and their offices were included in this study's assessment of institutional access to electricity. Government offices include local administrative offices and police stations in different states and counties.

Access to electricity

Overall, 83.5% of government and NGO offices reported not having electricity access. However, there were significant electricity access disparities between rural and urban areas, where 91.0% of rural government institutions reported no access compared to 49.9% in urban areas. Government and NGO offices primarily rely on off-grid technologies for electricity. Private micro- and mini-grids were the primary sources of electricity for most (46.0%) government and NGO offices with electricity access, followed by generators (27.1%), as shown in Figure 26 below.

FIGURE 26

Primary source of electricity for government institutions and NGOs



For government institutions and NGOs without access to electricity, affordability of off-grid solutions remains a key barrier, with 81.29% reporting that solar devices are too expensive. While 31.43% of government institutions received their solar devices for free, 43.93% purchased them, indicating some willingness to pay for them. In addition to affordability challenges, stand-alone solar products are also not widely available, as reported by 21.74% of government institution respondents.

3.2.4 Estimating the electrification and investment needs for Institutions

Given the currently low levels of energy access for South Sudanese institutions, this study attempts to estimate both total additional generation capacity and investment needed to electrify all health, education, and government institutions.

The methodology estimates energy needs for different types of health, education, and government institutions and then matches those needs against estimated costs for; i) introducing a solar PV solution to grid-connected facilities as a supplementary energy source; and ii) installing off-grid electrification solutions for facilities without access to electricity, that can meet those energy needs. Analysis based on this methodology found that a total additional investment of USD106,869,570 in off-grid solutions is needed to electrify all institutions currently without access to electricity and supplement the electricity supply for those institutions currently connected to JEDCO or another private mini- or micro-grid. A summary of the analysis findings for each institution type is shown in Table 3 below.

Table 3: Estimated capacity and cost for electrifying institutions through off-grid solutions

#	Type of institution	Total capacity needed (kW)	Electrification cost (USD)
1	Health institutions	7,587.03	16,793,452.00
2	Educational institutions	28,320.00	40,328,440.00
3	Government offices	18,137.00	49,747,678.00
Total		**51,922.03**	**106,869,570.00**

Source: Freepik

Methodology

Figure 27 below presents an overview of the methodology for simulating institutions' capacity and investment needs. First, simulations using HOMER software were made for a typical institution. The HOMER software models the optimal mix of power supply options that can meet a facility's electricity demand. For instance, a school that is already connected to a grid could be supplied by the grid alone if grid electricity supply is of a lower cost and meets the facility's electricity demand. However, if introducing an off-grid solution such as solar PV, reduces the final cost of electricity, the software computes the cost and the size of the solar PV that can be combined with the grid for optimised costs. If an institution is not connected to the grid, the software performs an analysis to identify the combination of technologies (in terms of their size and type) that offer a competitive electricity cost. For this study, the considered technologies included solar PV, battery energy storage systems, and diesel generators. An off-grid solution refers to a combination of solar PV, a storage battery system, and a diesel backup generator.

The HOMER outputs include i) simulated system capacity, ii) investment costs and iii) greenhouse gas (GHG) emissions for the simulated system. Lastly, the outputs were extrapolated to the total number of institutions in each category (education, healthcare, and government). According to the United Nations Office for the Cooperation of Humanitarian Affairs (UNOCHA), there are about 1,433 health facilities in South Sudan of which 80 are in Juba (OCHA, 2009). For this study, we classified the health facilities as follows;

i. 1079 public health units (PHCU),

ii. 306 public healthcare centres (PHCC),

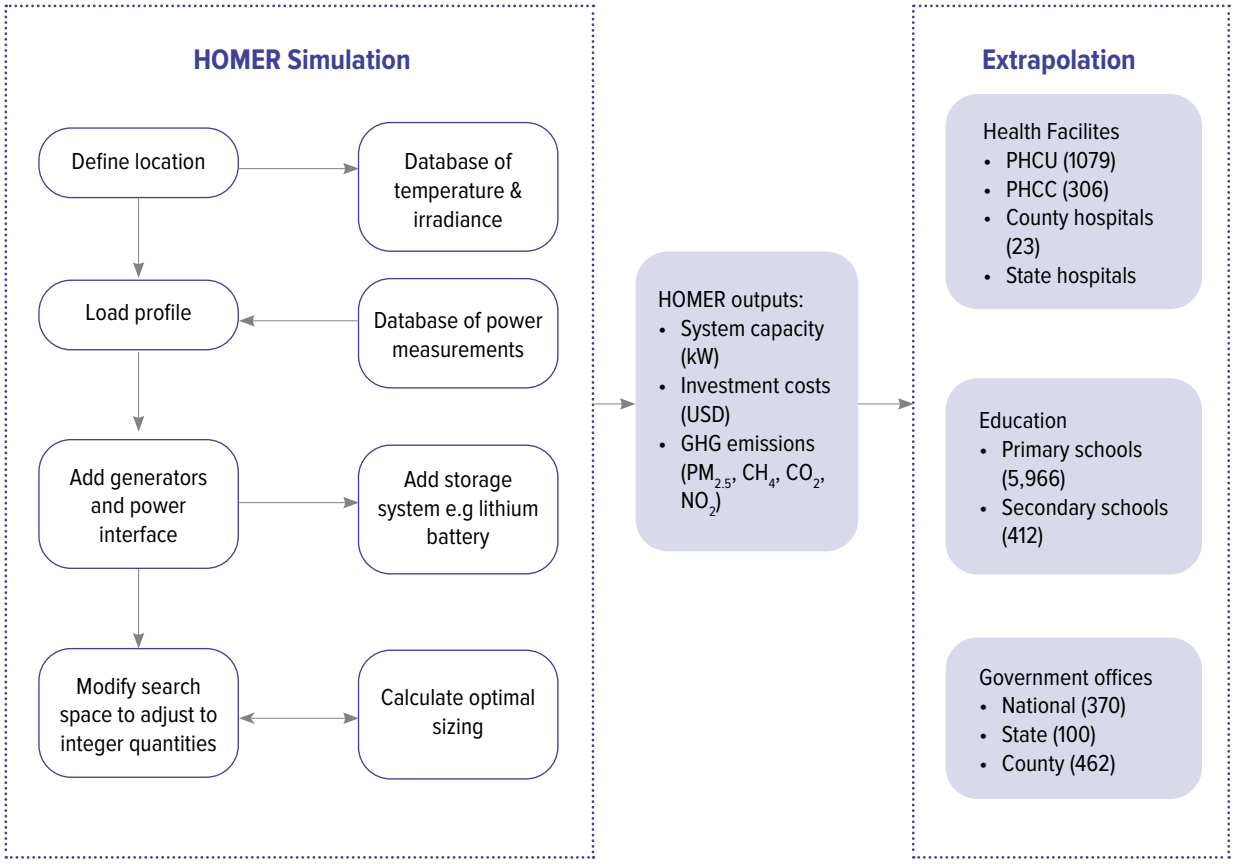
iii. 23 county hospitals; and

iv. 25 state hospitals.

Regarding education facilities, there were 5,966 primary and 412 secondary schools based on 2014 statistics (Ministry of Education, 2014). In Juba, a 2013 report showed that there were 153 primarily and 27 secondary schools (Longfield & Tooley, 2013).

FIGURE 27

Overview of the capacity and investment needs methodology



Estimated initial and ongoing costs for; i) introducing a PV solution to a grid-connected facility and ii) installing off-grid solutions (for facilities with no electricity access) were then applied to calculate the total investment need.

The estimated costs of the system were obtained from several sources, including the websites of common brands. The Table below shows the applied costs on important components of the system.

Table 4: Balance of system estimates

Balance of system	Cost (USD)
Solar photovoltaic (PV) panels (Center for Alternative Technologies, 2023a)	700 /kW
Inverter cost (MLT Power, 2023)	400 /kW
Battery energy storage cost (Center for Alternative Technologies, 2023b)	625 /kWh
Back up supply Balance of system	**Cost (USD)**
Diesel generator (Perkins, 2023)	250 /kVA
Cost of fuel (WFP, 2022)	2.00 /litre

Default software settings were considered in the cost of maintenance for solar panels, the battery storage system, and the converter system. These are illustrated below. A default discount rate of 8% and inflation of 2% are also applied as is in the Homer tool.

These assumptions are applied in the simulation of the subsequent institutions.

Table 5: Balance systems maintenance costs

Balance of system maintenance costs	Cost (USD)
Battery maintenance	10.00/yr.
Inverter maintenance	0.00
Generator maintenance	0.03/hr
Solar PV maintenance	10.00/yr.

Estimating the electricity needs for Health Facilities

The powering health tool, created by the United States Agency for International Development (USAID), is used to calculate the electrification needs for each category of healthcare facilities to give a high-level study of the energy requirements for these facilities (USAID, 2023). The loading estimates generated by this tool are integrated into HOMER software and the optimal combination of power supply options, namely, solar PV, diesel generators and batteries (USAID, 2023).

This analysis aims to provide the cost for power supply options that can adequately meet the energy needs of the different levels of health facilities. The following steps were used to generate the load profile and the estimates of the daily loads.

i. The powering health HOMER tool is used to calculate the selection of the load types that accurately represent the different classes of health facilities.

ii. The tool has four (4) classifications, including; (a) a rural dispensary with up to emergency beds, (b) a small inpatient clinic, (c) a rural hospital with up to 50-bed spaces, and (d) a district or referral hospital which is fully equipped and has up to 140-bed capacity.

iii. These four (4) classes are matched up with the present classes of surveyed health facilities – namely dispensaries/ Primary Health Care Units (PHCU), health centres / Primary Health Care Centres (PHCC), County hospitals, and hospitals. The hospital category consists of the state, specialised and teaching hospitals.

Table 6 below shows how the types of health facilities surveyed are matched to the powering health classifications.

Table 6: Matching up health facilities

Existing/Survey Category	Designated level of the facility using Powering Health Tool
Dispensary (PHCU)	Rural dispensary
Health Centre (PHCC) & private clinics	Small inpatient clinic
County hospitals	Rural hospital
Hospitals (state, specialized and teaching hospitals)	District/referral hospitals

Load and load profile assumptions and simulation outputs

The following assumptions on the load profile are based on the selected type of health facility and the variables obtained from the availability of the electric grid.

1. The PHCU takes a residential load profile in Homer with an estimated 5.7kWh average daily load.
2. The PHCC takes residential profile with an estimated 13.9kWh
3. The County Hospital takes a commercial load profile with an estimated daily energy consumption of 37kWhs.
4. The State Hospital takes a commercial load profile with an estimated load of 361.1kWh.

The simulations for the four (4) different categories of hospitals are performed in Homer software based on the assumed load profiles and energy requirements listed above. Three (3) costing scenarios are developed, and the costs associated with each scenario are calculated based on the stated inputs. The costing scenarios consist of:

(a) Cost estimates for introducing a PV option to supplement grid electricity: This refers to the scenario where the facility simulated is assumed to have a grid connection. The objective of such simulation is to find out whether introducing renewable energy sources such as PV, an energy storage system would bring down the Cost Of Energy (COE). This analysis is applied to:

- 70 grid-connected (89% of 80 health facilities in Juba-refer to Box 2) health facilities. The grid-connected health facilities are categorized as; i) 44 PHCU, 22 PHCC, 2 county hospitals, and 2 state hospitals.
- 103 grid-connected schools (57% of 180 schools – refer to Box 3) in Juba, which include 87 primary and 15 secondary schools and;
- 370 government offices – assumed to be the number of grid-connected Ministry offices in Juba (there are 37 ministries, and each is assumed to have ten departments hence one office for each).

(b) Cost estimates with off-grid connection: This refers to the scenario where the facility simulated does not currently have any access to electricity. The objective is to optimise the different types of energy sources, including solar PV, storage, and diesel generator, to determine the optimal size of each source that provides the least COE.

(c) Cost estimates with diesel generator only: This refers to a scenario where the facility only has access to a diesel generator. The objective is to estimate the overall lifelong costs of using a diesel generator, its COE, and by extension, the greenhouse gas emissions. The cost estimates for the diesel-only solution are presented in Annex 2

These objectives and classifications are applied in the subsequent simulations involving other institutions. It should be noted that the Homer simulation obtains the cost of electrifying one institution for each scenario. The obtained costs are scaled by the number of institutions within the simulated category.

Evaluated costs

The following outputs are obtained and presented for each set of the hospital, and subsequently for each institution.

a) Estimated initial costs: This refers to the total capital investment needed to build the proposed electrification system.

b) Estimated maintenance costs: This refers to the cost of system maintenance, repair and cleaning (for PV system) incurred in one year.

c) Levelized Cost of Energy (LCOE): This refers to the calculated optimal price as computed for the combination of energy sources in Homer.

Summarised Results for the Health Institutions

The tables below show the summarised costs associated with each different type of health facility. Detailed results on how this computation is arrived at are provided in Annex 2.

(a) Primary Health Care Units' total electrification costs

The off-the-grid system requires a 1.2kVA generator, a 2.83kW solar PV, a 5.00kWh battery system, and a 0.887kW converter. For the solar system to supplement a grid-connected facility, 1.65kW solar PV, 4.00kWh BESS, and 0.391kW inverter are needed. The estimated cost for electrifying one primary healthcare unit (PHCU) is USD 5,564 through an off-grid solution and USD 3,829 to introduce a PV system to supplement grid electricity. The total cost of electrifying 1,079 primary healthcare units is presented in Table 7 below.

Table 7: Estimated investment costs for electrifying 1,030 with an off-grid solution and introducing a PV system to supplement grid electricity for 44 PHCU with no inpatient

	Introducing PV system to supplement grid electricity (USD)	Off-grid option (USD)
Total initial cost	166,983.00	USD 5,730,920.00
Total operation and maintenance/ years	12,509.00	254,554.00
Levelized cost of energy (LCOE)	USD 0.256 /kWh	USD 0.333/kWh

(b) Primary Health Care Centre (PHCC) total electrification costs

For the proposed grid-connected system, we need a standard 4.13kW PV system, 1.03kW converter system, and 10kWh battery storage system. The proposed off-grid system requires a standard 7.06kW PV system, 2.16kW converter system, and 12kWh battery storage system combined with a 2.90kVA diesel generator. The estimated cost of electrifying a primary health care centre (PHCC) is USD14,638 through an off-grid system and USD10,223 for a PV system to supplement grid electricity for a grid connected facility. The total cost of electrifying 306 public health care centres with 4 inpatient facilities is presented below.

Table 8: Estimated investment needs electrifying284 PHCCs with an off-grid solution and introducing PV system to supplement grid electricity for 22 PHCCs

	Introducing PV system to supplement grid electricity (USD)	Off-grid option (USD)
Total initial cost	227,462.00	4,157,192.00
Total operation and maintenance/ years	13,501.00	172,328.00
Levelized cost of energy (LCOE)	USD 0.252 /kWh	USD 0.334/ kWh

(c) County hospital total electrification costs

A commercial load profile is applied here. This is premised on the fact that a health county hospital serves more people during the day, and it can be estimated that most of the electrical equipment is generally used during these hours. The demand, therefore, peaks at midday. The proposed grid-connected microgrid has the following technical specifications: 13.3kW of PV, 14kWh of Battery storage, and 4.12kW converter system and is coupled with the grid. The proposed off-grid system requires a standard 19.7kW PV system, 5.16kW converter system, and 16kWh battery storage system, combined with a 5.90kVA diesel generator. The estimated cost of electrifying one county hospital is USD 28,466 through an off-grid solution and USD 20,760 for a solar PV system to supplement grid electricity for a grid-connected facility. The total cost of electrifying 23 county hospitals is shown below.

Table 9: Estimated investment cost for electrifying 21 county hospitals with an off-grid solution and introducing PV system to supplement grid electricity for 2 county hospitals

	Introducing PV system to supplement grid electricity (USD)	Off-grid option (USD)
Total initial cost	41,520.00	597,786.00
Total operation and maintenance/years	2,044.00	24,927.00
Levelised cost of energy (LCOE)	USD 0.153 /kWh	USD 0.334/ kWh

(d) State / Teaching Hospital's total electrification costs

For the grid-connected system, 130kW of PV, 130kWh of storage, and 40.4kW converter coupled with the grid, is required. For the off-grid system, the following are needed: 192kW PV system, 58.0kW Generator system, 157kWh of battery energy storage, 52.2kW converter system. Table 10 below shows the summarised costs for state hospitals in South Sudan.

Table 10: Estimated Investment cost for electrifying 21 state hospitals with an off-grid solution and introducing PV system to supplement grid electricity for 4 state hospitals

	Introducing PV system to supplement grid electricity (USD)	Off-grid option (USD)
Total initial cost	753,892.00	5,620,902.00
Total Operation and maintenance/ years	41,076.00	234,843.00
Levelised cost of energy (LCOE)	USD 0.160 /kWh	USD 0.242/kWh

Estimating the electrification needs for education facilities

We used HOMER to approximate the cost of electrifying schools in South Sudan. The education facilities comprise 5,966 primary schools and 412 secondary schools. Table 11 below shows the total investment required to electrify 5,966 primary and 412 secondary schools in South Sudan. For primary schools, the off-grid solution includes a 1.2kVA generator, 3.72kW of PV, 3kWh battery storage and 1.04 converter system.

The PV system for grid connected primary school includes, 2.44kW PV, 3kWh battery storage and 0.775kW converter system. The off-grid solution for secondary schools includes 14.80kW of PV, 12kWh battery storage, a 4.0kW converter system and a 4.50kVA generator. The PV system for grid-connected secondary schools includes 9.72kW of PV, 11kWh battery storage and a 3.08 converter system.

The off-grid solution for secondary schools includes 14.80kW of PV, 12kWh battery storage, a 4.0kW converter system and a 4.50kVA generator. The PV system for grid-connected secondary schools includes 9.72kW of PV, 11kWh battery storage and a 3.08 converter system.

Table 11: Estimated investment costs for electrifying 5,879 primary and 412 secondary schools through an off-grid solution and introducing PV system to supplement grid electricity for 87 primary and 15 secondary schools.

No	Variable	Introducing PV system to supplement grid electricity		Off-grid option	
		Primary schools (USD)	Secondary schools (USD)	Primary schools (USD)	Secondary schools (USD)
1	Initial cost (A)	339,596.00	229,450.00	30,528,556.00	8,163,820.00
2	Maintenance/year (B)	15,846.00	10,978.00	1,290,688.00	345,376.00
3	Total (A+B)	355,442.00	240,428.00	31,819,244.00	8,509,196.00

Estimating the electrification needs for government offices

The following assumptions were considered in estimating the investment needed to electrify government offices in South Sudan.

a) There are 37 ministries at the national level, each consisting of ten departments. Thus, each department would have an office. Thus, the total number of government offices considered are 370. We assume that all the 370 ministry offices are grid-connected.

b) Each of the 10 South Sudanese states requires one office for the governor and nine offices for state ministries. Thus, the total number of state offices is 100.

c) Each county requires six offices, and since there are 77 counties in South Sudan, the total number of county offices will be 462.

d) The total capacity required to power one office is 19.46kW (see more details on appliances and energy requirements for a typical office in annexe 2).

Table 12: Estimated investment costs for electrifying 562 government offices through an off-grid solution and introducing PV system to supplement grid electricity for 370 offices

No	Variable	Introducing PV system to supplement grid electricity (USD)	Off-grid option (USD)
1	Initial cost (A)	26,190,080.00	47,956,022.00
2	Operation and Maintenance/ year (B)	1,022,310.00	1,791,656.00
3	Total (A+B)	27,212,390.00	49,747,678.00

4. Supply side Dynamics of the Off-Grid Sector

4.1 Introduction

This section provides an overview of the off-grid energy supply chain in South Sudan, focusing on the solar off-grid and mini-grid markets. It identifies key players in the solar off-grid and mini-grid product and service supply chain and highlights the brands and models of modern standalone solar products. The different actors within the market are examined to capture the operational history of the enterprise, their target market segments and market share, types of products and services offered, and marketing, promotion and distribution strategies employed. The section concludes with the perceived constraints and opportunities that the market players experience within the South Sudan off-grid supply chain.

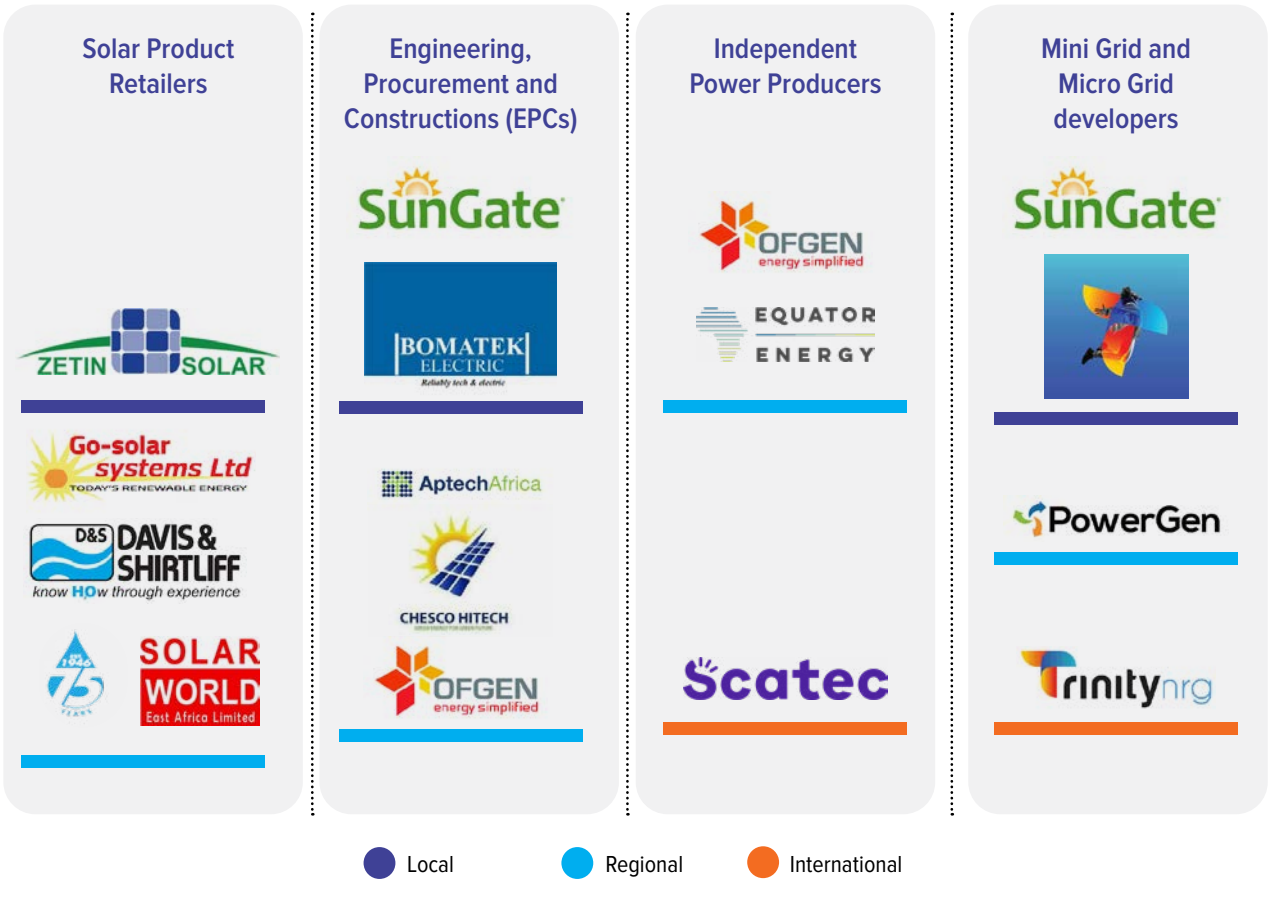
4.2 Mapping of the Off-Grid Solar Companies

The solar PV market in South Sudan is growing steadily, but minimal information is available. Additionally, most companies operating in the country within the value chain do not have an online presence. As such, the study mainly relied on primary information collected from the companies with which key informant interviews were conducted. Secondary data is used where available to support these findings. The market players are categorised into international, regional, and local South-Sudan based companies.

A summary of the off-grid companies is presented in Figure 28 below.

FIGURE 28

Mapping of the off-grid companies operating in South Sudan



Product Offering, Target Market Segment, Marketing and Distribution Strategies

Most off-grid solar companies in South Sudan primarily serve large institutions and commercial customers, who account for more than 80% of their sales. Many of the off-grid solar companies indicated that they prefer serving international NGOs and other aid organisations operating in-country, as these organisations have both the willingness and ability to pay. Hence the household market is underserved due to several factors, including affordability, availability and lack of awareness. The procurement cost and high transportation, and informal and formal taxation costs drive product pricing. A few companies have tested a pay-as-you-go (PAYGo) model to offer consumer financing for their products, but with poor repayment results. The primary issue reported was the devaluing of the South Sudanese currency, which affected consumers' purchasing power.

The off-grid solar companies mainly import parts from manufacturers and assemble them in South Sudan for sale and installation. Bomatek, for example, procures its supplies from African Energy, a company based in Arizona, USA. African Energy has depots in 9 African countries, including Nigeria, Tanzania, Sierra Leone, Zimbabwe, Uganda, Zambia, Liberia, Kenya, and Burkina Faso, where it distributes its products. Aptech Africa is an example of a company sourcing solar products regionally from Soleil Power, a manufacturer headquartered in Uganda. Aptech also imports solar pumping solutions from Victron Energy, a Netherlands-based company; Grundfos Pumps Corporation, based in Texas, USA; and Lorentz, headquartered in Germany. Davis and Shirtliff manufacture and assemble imported parts at its headquarters in Nairobi. It sources the parts from companies worldwide, such as Huawei, Topray, Yingli, and Amerisolar, which manufacture their products in China. It also imports products from Victron and Grundfos.

Source: Shutterstock

Companies rely on third-party distributors and resellers to serve customers outside of Juba. For example, Aptech has its transportation for distribution within Juba state but has one third-party distributor serving the rest of the country. Davis and Shirtliff have offices in Juba but distribute products to other states through resellers. Chesco hi-tech has a transport team to distribute products from Juba to its customers, but it also relies on third-party distributors in Wau, Juba and Malakal. Traders are generally expected to pay 100% upfront, whereas institutions such as NGOs pay 30 days after delivery and installation.

Most companies interviewed in the study do not undertake elaborate marketing efforts to create awareness about their products but instead rely on referrals and inbound clients. For example, Bomatek finds and responds to tenders for solar system installations, especially from NGOs. It also receives referrals from customers who have been in the market for over 10 years. Aptech Africa does not actively market its products and services either, as most (90%) of its customers are NGOs who approach them.

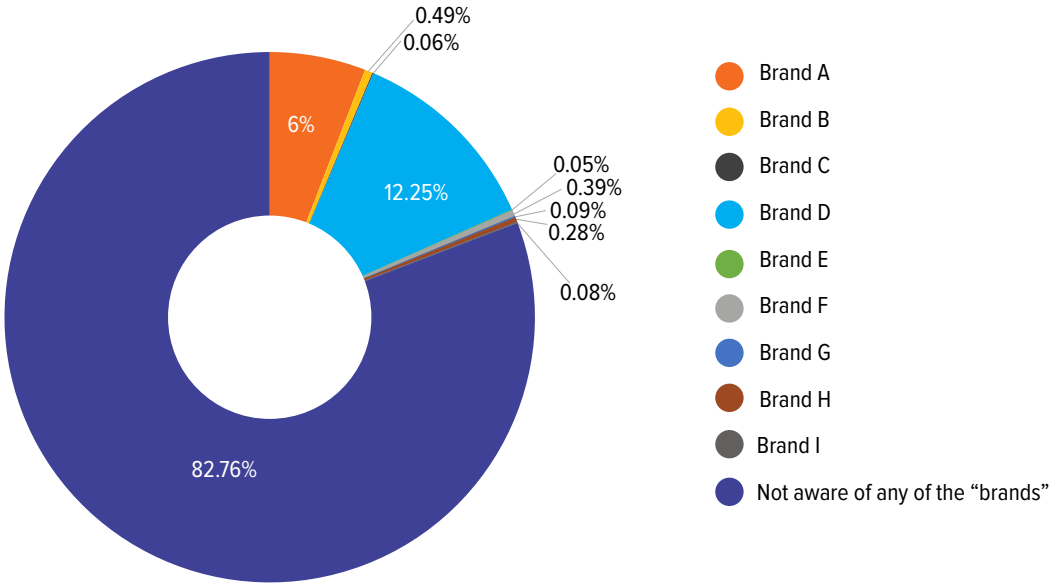
Detailed profiles of the off-grid solar companies operating in South Sudan can be found in Annex 7.

4.3 Brands and models of SAS systems in the market

Familiarity of households with stand-alone solar products is an indicator of availability of the products in the market. While most (91.59%) respondents were aware of solar devices 82.76% of respondents were not aware of the 9 brands of stand-alone solar products sold in South Sudan (Figure 29). Meaning that off-grid solar companies had not adequately penetrated the market. The percentage distribution of brand awareness among the survey respondents is summarised below.

FIGURE 29

Awareness of Brands of Solar Devices in South Sudan



4.4 Privately owned micro and mini-grids in South Sudan

Very limited number of private developers were identified during the interviews. Several companies have developed and operate mini-grids in South Sudan, as summarised in Annex 4. Data on type, number of end users, and retail tariffs were unavailable for all companies apart from SunGate Solar.

Mini-grid developers such as Aptech, Power Gen, and SunGate have identified potential sites across the country for the installation of microgrids, mostly in state capitals and urban cities. Some of the reasons for selecting the potential sites include:

- Key trading towns which are strategically located at border points.
- Administrative towns with a large presence of government offices and NGOs.
- Transportation hubs where there are good access roads.
- Towns with adequate security and peace.
- Highly populated towns with growing economic activity.

4.5 Constraints in the Supply Chain

a. Unfavourable Legal and Regulatory Environment

The lack of regulations within the renewable energy sector in South Sudan was highlighted by majority of the respondents as a constraint to the growth and development of the off-grid and mini-grid supply chain. Most policies and regulatory frameworks governing South Sudan's electricity sector are either in draft forms or are proposed ideas and do not include a strategy for promoting renewable energy technologies (Lemi & La Belle, 2020). As a result of a poor regulatory environment, the market is characterised by substandard products and non-qualified technicians. According to one of the enterprises engaged in the study, the suppliers who offer higher quality products at a higher price point can thus not compete effectively with the cheaper low-quality products. This observation is echoed in the GOGLA Off-Grid Solar Market Trends Report 2022, which concludes that sub-standard products reduce customer confidence and can negatively impact the sales of companies offering high-quality products (Lighting Global et al., 2022).

There is minimal regulatory support for off-grid solar from the South Sudanese government, compared to Kenya, Uganda, and Rwanda, where the market is growing steadily (Hankins, 2019). Private companies are therefore discouraged from entering the market due to the challenging business environment (Altai Consulting, 2014). A stable regulatory environment is also critical in assuring private investors that their property will not be expropriated (SEforAll, 2013). South Sudan lacks formal duty exemptions, enforceable standards, codes of practice, and licensing of traders and solar technicians (Hankins, 2019). The high import, domestic, official, and unofficial taxes, which, when combined, are higher than the official tax rate of 50%, is a significant constraint to all enterprises in the supply chain (Altai Consulting, 2014). These taxes result in high transportation costs and, subsequently, high product costs transferred to the end user.

b. Insecurity and Poor Infrastructure

Insecurity is a bottleneck in the supply chain which limits the expansion of the off-grid solar market. For example, one respondent recounted how they lost stock when they were robbed in 2018 while travelling to install a solar system in a hospital in Bor. In a study undertaken by Lighting Africa, a transporter emphasised that clashes result in the diversion of trucks to longer routes or completely halting journeys, leading to client dissatisfaction. Others reported theft along the transportation route or dangerous situations when they could not pay through unofficial checkpoints (Altai Consulting, 2014).

Poor transport infrastructure in South Sudan is a significant impediment to economic activity and limits the distribution capacity of the suppliers. The poor road network results in trucks carrying smaller loads and longer travel times, which increases the average unit cost of transportation (Ranganathan & Briceño-Garmendia, 2011). Additionally, many parts of the country become less accessible or inaccessible during the rainy season, thus necessitating the use of multimodal transport, such as river transport, which is also underdeveloped (Ranganathan & Briceño-Garmendia, 2011). As a result, some transporters experience decreasing business of between 15-100% and longer journeys by up to 3 days (Altai Consulting, 2014). For example, one respondent gave an account of spending two days in a river trying to transport goods to the Lakes state owing to the use of substandard boats.

Due to these factors, transporting goods in the country is generally expensive (Altai Consulting, 2014). To put this into perspective, the average tariff paid to transport goods from Mombasa, Kenya to Kampala, Uganda, is approximately $0.06 per tonne-kilometre, while that between Juba to Kampala is three times more at $0.18 per tonne-kilometre (Ranganathan & Briceño-Garmendia, 2011). There are also many checkpoints that trucks must go through by making formal or informal payments. A respondent from the study estimated that when transporting goods from Juba to Malakal, one could pay between $100-$1,000, thus affecting the final cost of products sold to the consumer. Overall, this results in a poor enabling environment to conduct trade.

c. Access to Finance

The lack of access to finance was identified as a critical barrier to developing the off-grid and mini-grid supply chain in South Sudan. One of the respondents in the study reported that financial institutions charge high interest rates, up to 22%, thus making it unattractive to borrow money to expand business activities. Another respondent mentioned that they often borrow from individuals to finance their operations at interest rates ranging from 20-30% per month. Financial institutions were reluctant to lend to off-grid solar enterprises since they had no asset-based collateral. A lack of access to finance constrains the ability of retailers to operate at scale and increase the volume of sales, which impacts the consumers at the end of the supply chain who can't pay upfront for these products and service offerings (Altai Consulting, 2014). The 2022 Off-Grid Solar Market Trends Report notes that a critical barrier to expanding off-grid solar in new markets is the lack of equity, grants, or Results Based Financing (RBF), which has led to stifled growth among many companies (Lighting Global et al., 2022).

d. Lack of technical capacity

Another impediment to developing the off-grid solar sector in South Sudan is the limited capacity of technicians to install, maintain and repair the solar systems (Mozersky & Kammen, 2018). In another study (Hankins, 2019), visits to different sites revealed several challenges, including poorly installed and wired solar systems, unprotected batteries and inverters in indoor spaces, and improperly fixed solar arrays. Another example is where a solar PV system worth $20,000 could not be operated due to a broken inverter that the supplier could not repair or replace (Hankins, 2019). Lack of access to skilled technicians, especially in remote areas, to repair damaged or malfunctioning parts of solar systems resulted in reliance on generators (Hankins, 2019).

e. Fluctuating Local Currency and consumer awareness

A respondent remarked that the fluctuating and devaluing of the South Sudanese Pound significantly affect purchasing power of potential customers, thus limiting the expansion of the off-grid solar market. One of the contributors to this decline is the rapid devaluation of the South Sudan pound, which has increased prices of all commodities, including staple foods and diesel fuel (Mozersky & Kammen, 2018). Insufficient affordability is a significant obstacle in adopting solar home systems among households, as they have limited financial resources to afford the product, and the unavailability of financing options for rural households compounds the problem (Kizilcec & Parikh, 2020).

Consumer awareness of solar power products and benefits is low, including individual and business consumers (Altai Consulting, 2014). This can be attributed to limited marketing and product promotion by manufacturers not based in the country. The manufacturers thus pass the responsibility to retailers and distributors with insufficient capacity to conduct marketing and promotions (Altai Consulting, 2014). Consequently, sales volumes are low due to the limited awareness, leading to reduced investment by manufacturers in local marketing efforts. In turn, the cycle of limited awareness continues to perpetuate (Altai Consulting, 2014). Without consumer awareness, the design and procurement of solar systems is hindered, the systems are poorly managed, and poor or substandard products or equipment are purchased (Hankins, 2019). These factors hinder the development of the sector.

5. Assessment of the Local Financing Market for Standalone Solar and Mini-Grid Services

5.1 Overview of the Financial Market

Where governments lack the resources to deliver universal energy access through subsidised grid extension, the private sector can play a vital role in filling the gap especially through off-grid solutions (GOGLA, 2015). But private sector companies offering these off-grid solutions in South Sudan require financing to grow, and many South Sudanese consumers require financing to afford off-grid solutions.

Due to the significant exchange rate risks associated with hard currency debt, there is an opportunity to leverage local currency financing from domestic financial institutions to offer competitively priced credit terms, especially for the off-grid sector (African Development Bank, 2020a).

The subsequent sections aim to assess the local financing market and its capacity to provide standalone solar and mini-grid financing services through:

i) An overview of the local financing market in South Sudan – a description of the sector players (commercial banks, microfinance institutions, development finance institutions, expert credit agencies and major credit unions and savings cooperatives and mobile money).

ii) An overview of the commercial lending environment to both businesses and consumers, including the interest rates, collateral requirements, typical loan sizes, and barriers to financing access.

iii) An assessment of the interest of financial institutions to lend to the off-grid industry through the level of awareness, capacity, and interest.

5.2 Sector players

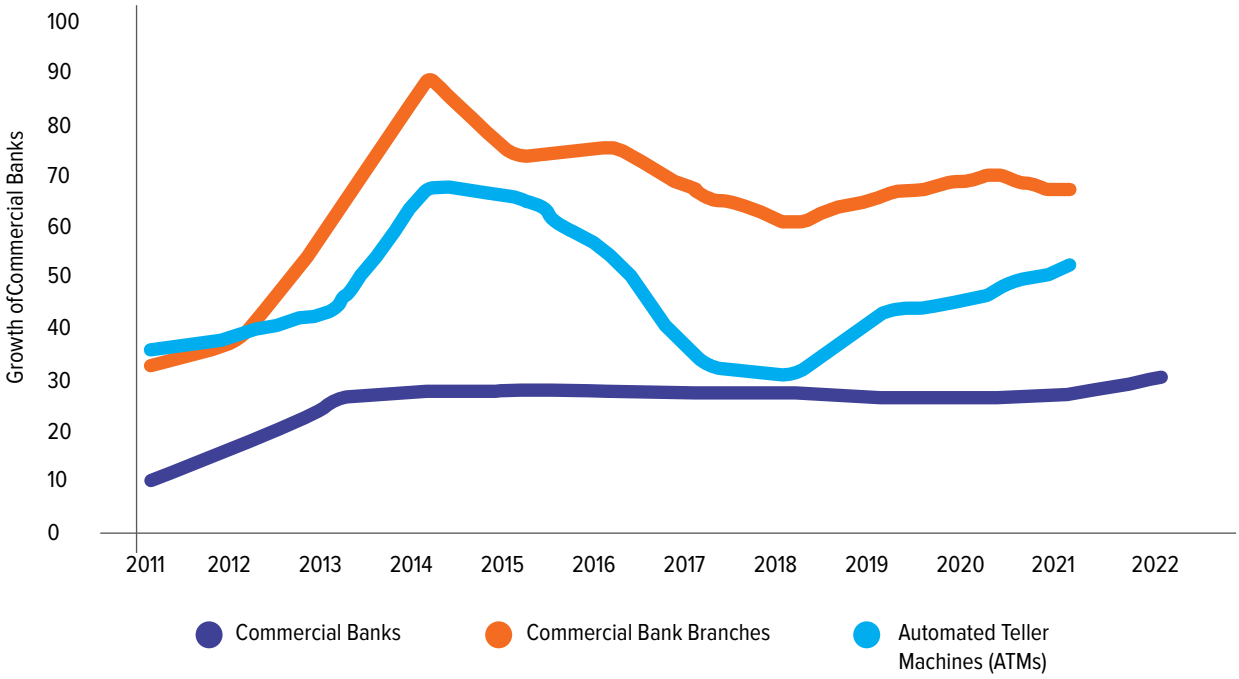
Commercial Banks

As per the Central Bank of South Sudan (BOSS) (Bank of South Sudan, 2023), there were 30 commercial banks in 2022, growing steadily from about ten banks at independence (World Bank, 2023a), as shown in Figure 30. The leading banks dominating the sector, Kenya Commercial Bank (KCB) South Sudan, Equity Bank, Eco Bank South Sudan, Cooperative Bank South Sudan, Nile Commercial Bank and Charter One Bank, are foreign-owned, originating from neighbouring countries such as Kenya (Altai Consulting, 2019).

Source: Freepik

FIGURE 30

Growth of Commercial Banks, ATMs and Bank Branches in South Sudan



A complete list of banks in the country is provided in Annex 3.

Commercial banks have relatively few borrowers, with about 0.9 per 1000 adults (World Bank, 2022b). In South Sudan, foreign and local banks have a cautionary approach to lending and do not offer loans for energy-related activity, as inferred through the types of loans they offer. Equity Bank South offers short-term loans with a tenor of between 1-3 years, designed to meet individual and business needs. The minimum loan limit is SSP 50,000, while the maximum is SSP 3.5 million. This is equivalent to $385.85 and $26,869, respectively. The types of loans offered include education, medical and working capital loans. Working capital loans could be used to finance already existing off-grid businesses; however, to access this loan, the businesses must provide substantial financial information, collateral security, and a clear purpose for the use of funds. The KCB bank offers SME and business loans with up to 60 months of repayment. The loan amount is dependent on the customer's repayment capabilities, the type of collateral presented and audited accounts over the last three years. This must be provided for all applications above SSP 250,000. Collateral could be land titles, car logbooks, stock price lists and verifiable personal assets. The interest rate of commercial banks is 16.1% (World Bank, 2022c).

MFIs and Village and Loans Savings Associations

The microfinance sector in the country is relatively undeveloped. However, in 2019, there were 11 microfinance institutions with estimated 51,092 customers and 36,446 borrowers (Feather et al., 2019). The formal microfinance institutions established by non-governmental organisations include BRAC South Sudan, Finance South Sudan Limited, Humanitarian Southern Sudan, Rural Finance Initiative, Women and Youth Empowerment Microfinance Initiative, Sudan Microfinance Institution and Manna microfinance which is part of the diocese of Juba. Microfinance institutions offer loan services (microloans) with a payment period of between 6 to 24 months and varied interest rates, ranging from as low as 3% to 30% (Feather et al., 2019; Manyuon, 2020)

However, there is a thin line between these microfinance institutions and local saving and credit groups, also known as Village Saving and Loans Associations (VSLAs). These groups are highly relevant for a predominantly cash-based economy to fill the gap left by formal financial institutions (IMF, 2022). They range from informal and traditional groups where members rotate funds, save and borrow money for activities such as purchasing household items to organised groups

equivalent to formal microfinance institutions (Feather et al., 2019). VSLAs, established by several non-governmental organisations, are widely spread across South Sudan. The groups fit the dominant cash economy and the low awareness of formal banking services. Some of the VSLAs established to include the following:

i. The Anglican International Development Organisation established two microfinance programmes in Yei and Juba (Anglican International Development, 2023).

ii. Women's Worldwide web (W4) launched microfinance to support 200 women. Each woman is given a loan of USD125 annually at 20% interest (W4 (Women's Worldwide Web), 2022).

iii. Shared Accountability, Lending and Teaching (SALT) microfinance solution established by Christian aid ministries (Christian Aid Ministries, 2020).

iv. Catholic Relief Services (CRS) created over 1,100 groups with at least 27,586 active members (21,315 of these are women) (CRS, 2018).

v. Five Talents established three community banks and several community-owned and led saving groups that have served over 40,000 people with loans and saving serves (Fivetalents, n.d.).

vi. Mother's Union (Mothers Union, 2023) also runs micro-finance projects in the form of VSLAs in the Country.

vii. The EU Rural Development Programme established and supported 1000 VSLAs in the Greater Bahr el Gazal and Upper Nile region. By the end of the first quarter of 2021, the average group savings amounted to 14,182,980 South Sudanese Pounds (SSP) (Alabi, 2021)

viii. CARE South Sudan created 170 VSLAs with over 4000 members under the Addressing Root Causes of Conflict (ARC) programme (Whipkey, 2021).

ix. By 2017, 45 VSLAs were created by ACTED.

Beyond the saving and credit services offered by these community groups, they are also used as avenues for financial literacy. However, conflicts, natural disasters, infrastructural challenges, and other factors constantly affect the groups' structure, operations, and cohesion (ACTED, n.d.).The Village Savings and Loan Associations (VSLAs) are perhaps the most common loan source for most people, especially in rural areas (Alabi, 2021). Households use these funds for several purposes, such as the establishment of small businesses, shelter upgrades and purchasing household items (that may include solar products) (Alabi, 2021). The typical interest rates offered by these groups range from 10- 15% for members and 20 to 30% for non-members (Alabi, 2021; Feather et al., 2019).

Mobile Money Services

Mobile money services, which have been key in enabling consumer financing for off-grid solar products in other markets, are still in the infant stages in South Sudan because of a weak telecom sector (Altai Consulting, 2019). This study revealed that only 8.5% of the head of households (all in urban areas) had a mobile bank account. This makes it difficult for financing institutions to reach more customers and for solar companies to sell their products. The Bank of South Sudan granted a licence to two third parties for mobile money operations (Jenefer, 2022). These are M-Gurush and Nile Pay. Nile pay had about 103,400 customers and 3000 branches spread across South Sudan (NilePay, 2020). Other telecom operators interested in licenses include MTN South Sudan and Zain.

A report by Altai Consulting presented several challenges that impede cellular connections and mobile phone ownership (Altai Consulting, 2019). These include infrastructural challenges (such as poor network coverage, especially in rural areas and lack of electricity to charge phones) and high upfront costs of purchasing mobile devices. In 2022, there were 3.27 million cellular connections, representing about 28.4% of the population (Kemp, 2022). However, some individuals have more than one mobile connection; hence, the number of mobile connections may be higher than the corresponding population (Kemp, 2022). In addition, the country has a high corruption index, making financial experts and businesses call for proper accountability measures, including vetting mobile companies and procedures and adherence to customer confidentiality.

only
8.5%
of the head of households (all in urban areas) had a mobile bank account.

Common challenges to mobile money penetration and access in the country include low SIM card ownership, long distances to mobile money agents, low ID ownership and high rates of general and financial illiteracy (Altai Consulting, 2019; IMF, 2022). In addition, a survey by Altai consulting in 2019 established that one-third of the population (30 per cent) believe money transfer services are insecure and unreliable. In rural areas, at least 83% of residents must travel at least 30 minutes on foot to reach the closest mobile network operator's branch or agent.

Agents are significantly more reachable in urban areas, but 40 per cent of urban residents still must travel between 30 minutes and 2 hours to reach the closest agent. Similarly, the average cost of travelling to get an agent is three times higher for rural residents than for urban residents. This is exacerbated by 41% of the population having no form of identification that could help them register for mobile money services.

The average cost of travelling to get an agent is three times higher for rural residents than for urban residents. This is exacerbated by 41% of the population having no form of identification that could help them register for mobile money services.

Source: Freepik

5.3 Financing for the Off-grid Sector

5.3.1 Barriers to consumer financing

Low access to financial services translates to limited access to consumer financing for off-grid solar products. From the survey, only 7.8% of urban and 0.3% of rural households said that they had savings accounts with a formal institution. Respondents reported a similar trend (urban: 92.22% and rural: 97.80%) regarding having an informal savings account. Approximately 7.39% of households reported having a commercial bank account, while there were none (0%) in rural areas with a commercial bank account. Furthermore, few urban (0.24%) and rural dwellers (0.24) had an account with a microfinance institution.

Rotational group savings was the predominant informal savings system in which about 6.43% of urban and 2.02% of rural households reported having an account. Additionally, 1.35% of urban and 0.17% of households reported having a one-time disbursement group savings account. The most likely lenders from whom respondents could take loans were;

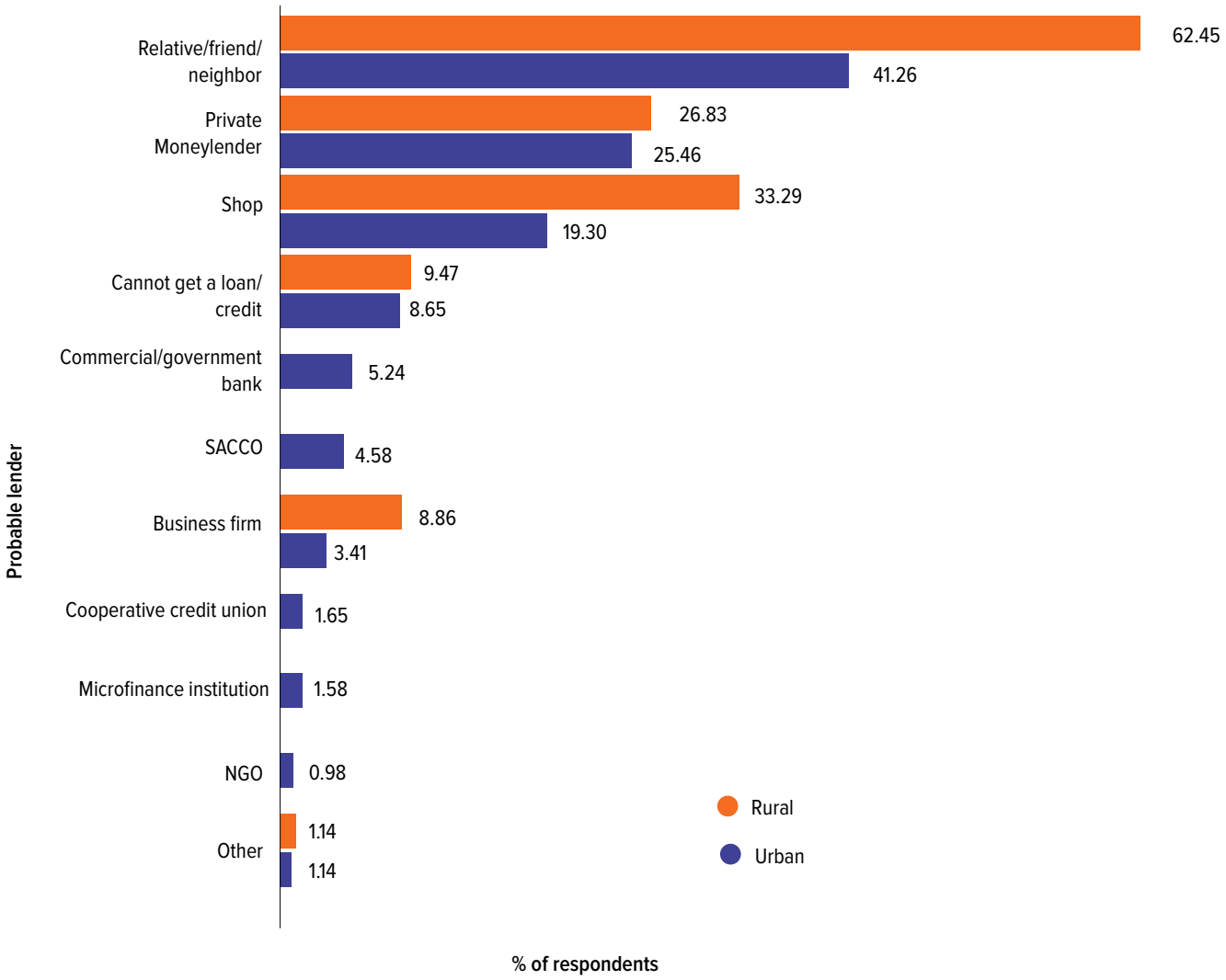
i) relatives, friends or neighbours (urban: 41.26%, rural: 62.45%),

ii) private money lenders (urban: 25.46%, rural: 26.83%), and

iii) nearest shop (urban: 25.46%, rural: 33.29%) as shown in Figure 31 below.

FIGURE 31

Probable lender as reported by respondents



According to World Bank data, less than 600,000 of the over 11 million South Sudanese use the banking sector (World Bank, 2022a). This translates into only 5.83% of those aged 15 and above having an account with a financial institution, including mobile money service providers. The low levels of access to financial services are attributed to several factors, including limited financial (and general) literacy, infrastructural challenges, insecurity and low awareness and familiarity with formal financial systems (Altai Consulting, 2019; IMF, 2022). In addition, according to the International Monetary Fund (IMF, 2022), the high costs of doing business due to poor infrastructure, lack of electricity, poor communication channels and low-developed transport systems, among other factors, is a significant barrier to the expansion of banking services.

5.3.2 Barriers to lending to off-grid companies

Based on the overview presented, the challenges to lending as highlighted by banks and the off-grid energy companies include:

- **High interest rates and short loan tenure terms.** "Interest rates are regulated by the Bank of South Sudan (BOSS), however, banks still charge interest rates at their own discretion " *[KII- Financial Expert].* The high interest rates have negative consequences in terms of loan availability to energy companies and consumers. The short loan tenure terms also have implications for the companies interested in offering consumer financing for solar lighting products that may require long-term financing.

- **There is no informative infrastructure for credit data, credit scoring, or registering credits, which would establish confidence and promote growth (World Bank, 2019).** Commercial banks in South Sudan face difficulties in providing financing due to the fact that records used to verify documents provided as collaterals are outdated and sometimes not available[KII- Financial Expert]. "The lack of records means that banks can not lend to those in need of financing. In addition, the financial expert indicated that they have been situations in which a loan has been provided to an individual or company and the bank ends up having individuals/ companies with similar title deeds they have placed as collateral" [KII- Financial Expert]. The financial expert stated, "Risk appetite is always there if the borrower can provide compelling security on the loan. There are lots of questionable properties and banks tend not to dwell over these properties. Interest in lending is a case-by-case" *[KII- Financial Expert].*

- **Low interest and risk appetite for banks to lend to the off-grid sector.** The ability to lend is centred around the specific bank's risk appetite. In a key informant interview with a financial expert, it was established that risk appetite is key determinant to the banks' ability to lend to the off-grid sector. The financial expert stated, "the capacity and interest to lend to the off-grid sector depends on the respective bank's risk appetite; some banks may choose syndication if they cannot provide enough funds on their own. Most of the banks do have regional connections and they refer their deals to their headquarters" *[KII- Financial Expert].*

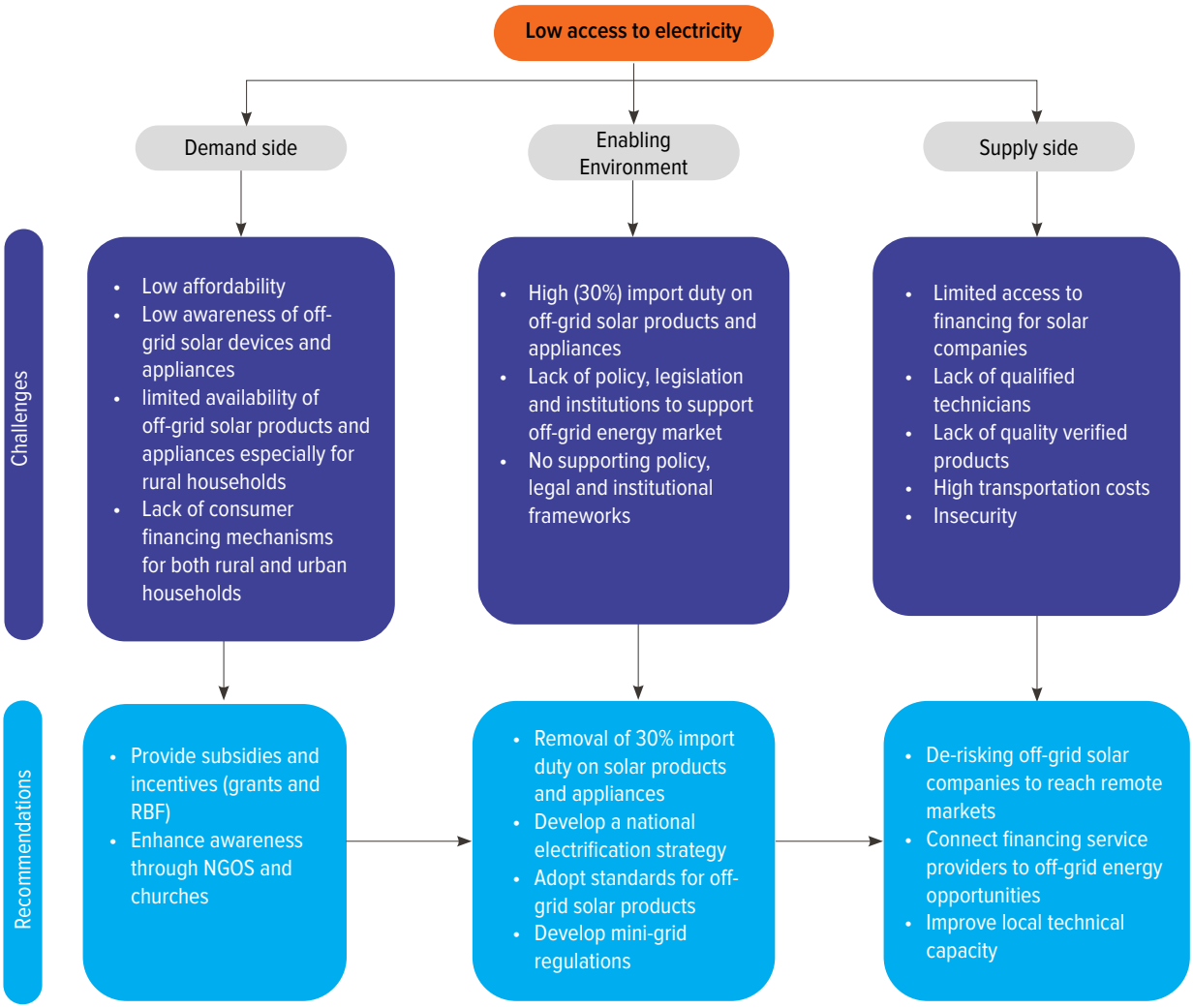
Emphasis on collateral financing rather than project financing for energy companies. An in-depth key informant interview by one South Sudanese bank mentioned that they had been approached by solar system dealers to set up a facility to provide access to credit to final customers using the solar system devices themselves as collateral. The bank considered that the default risk on such loans would be too high, notably because solar systems are not valuable collateral and collateral is difficult to claim back due to the weak legal environment and security risks in some rural areas in South Sudan. The bank had also been approached by an entrepreneur who wanted to set up solar franchises throughout the country, by identifying local entrepreneurs with business potential and training them in Juba on sales, maintenance, and installation. According to his business model, products were to be sold to these franchises at a 30% discount, with bank loans to the franchises, financing 50% of the remaining cost, which they would repay after selling their products. The 30% discount would mean that products could be sold across the country at a similar price as those in Juba, attracting more customers. However, the bank considered the project too high risk, as they felt that borrowers in rural areas could easily disappear with the loans. "...lending to small businesses in rural areas is "dangerous" for debt collectors, as borrowers in default can use violent means to prevent debt collectors from collecting collateral". *[KII- Bank]*

6. Conclusions and Recommendations

6.1 Conclusions

6.1.1 Summary of challenges and recommendations

FIGURE 32
Summary of challenges and recommendations



→ Demand-side: Access and affordability gaps limit growth in electrification rates

South Sudan has an electrification rate of 5.4%, one of the lowest electrification rates in the world and is also one of the few countries where decentralised (off-grid) approaches provide energy access to most of those who have access. For example, the aggregated capacity of stand-alone generators is estimated to be higher than the grid-connected operational generation capacity. This presents an opportunity to build a modern and robust electricity sector that fully integrates decentralised, off-grid approaches.

However, the access gap (lack of availability of off-grid products) and affordability gap (the inability to acquire off-grid product due to financial limitations) in South Sudan are extremely wide.

The relatively high poverty levels and lack of regular income among potential clients contribute to the affordability gap. Therefore, most households cannot consistently pay for energy products even with financing over extended periods. This is driven by low-income levels and a lack of consistent and predictable income streams. Consumer financing has the potential to address affordability issues. However, the lack of traditional consumer financing for off-grid products and a nascent mobile money sector that does not support PAYGo models alienate potential consumers. The access gap is driven by the lack of availability of off-grid products in rural areas where most of the off-grid population resides.

Limited awareness and exposure to off-grid technologies constrain demand for off-grid electrical products.

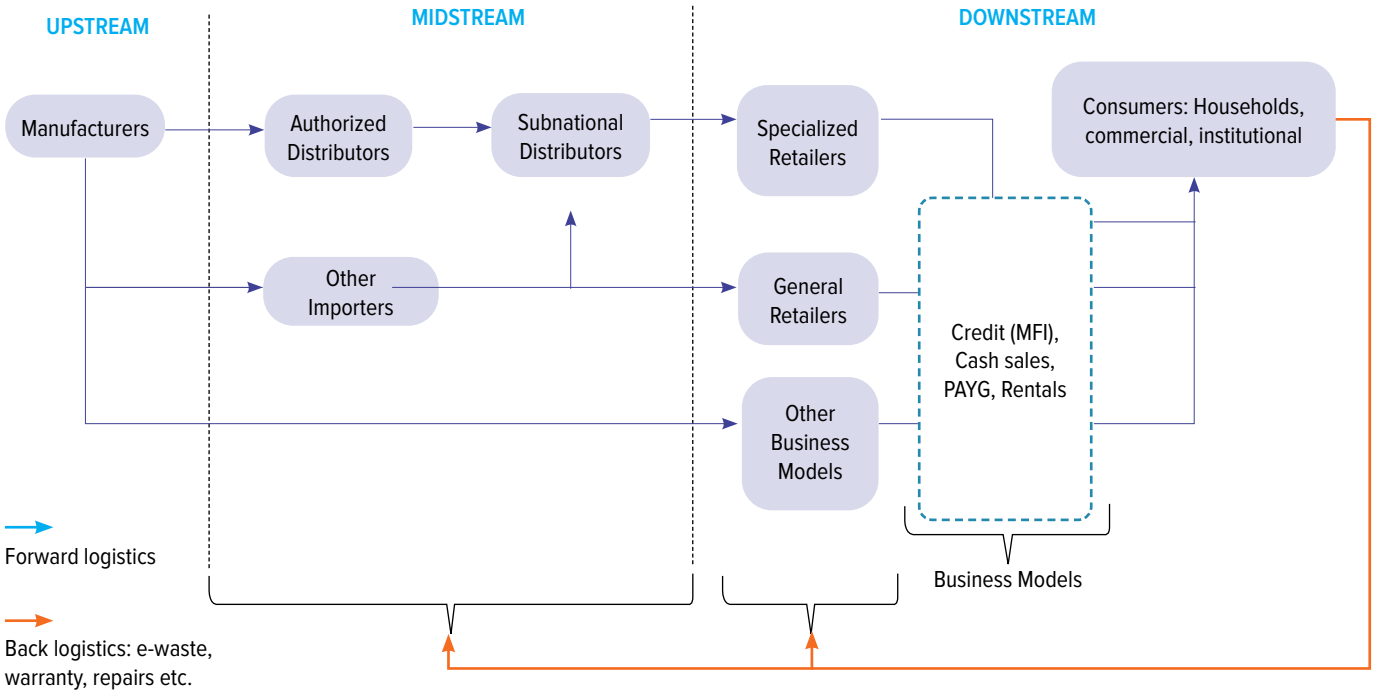
→ Supply-side: Lack of quality verified products, limited and high-cost distribution channels, and a small target market dominated by donors lead to an underdeveloped sector overall

On the supply side, the off-grid sector is underdeveloped due to a lack of quality verified products, limited and high-cost distribution channels, and a small market of consumers who can afford to pay. Two other key challenges are a lack of access to financing and an inadequate enabling environment, which are addressed in subsequent sections.

Based on independent sources from consumers and suppliers, most off-grid energy products available in South Sudan are neither standardised nor quality verified. This hinders uptake, as many households reported quality to be a main factor in their purchase decision, especially in urban areas. In addition, very few consumers receive warranties on their purchases, which damages consumer confidence in off-grid solar products and disproportionally affects consumer willingness to purchase higher-cost, higher-tier systems. Since almost all purchases are paid for with cash upfront, this further amplifies consumers' perceived risk. Manufacturers need to have proper channels for employing third-party distribution models to ensure customers access warranty and after-sale services. This can be done by entering into a partner or service agreement where the distributor honours the warranty and later claims it back from the manufacturer. Service and maintenance are also key in ensuring that consumers have their products repaired and serviced should the need arise. A typical distribution model employed by many mainstream solar companies is shown in Figure 33 below.

FIGURE 33

Common distribution models employed by solar companies; Source: EED Advisory, 2021



Off-grid solar companies operating in South Sudan also contend with high distribution and transportation costs, often relying on third-party distributors outside Juba. Unlike other markets in East Africa, most South Sudanese consumers purchase off-grid solar products from general merchants and retailers, rather than directly from off-grid companies or specialised distributors. Most off-grid companies do not have extensive distribution networks in rural areas, and those who do encounter a host of both formal and informal taxes while moving goods throughout the country, as well as poor infrastructure and transportation delays. Companies then have to pass these high distribution costs to consumers, further exacerbating the affordability and accessibility gaps on the demand side.

Lastly, off-grid companies struggle to grow due to the small market size that can afford to pay for their products and services. Development and humanitarian agencies have an outsized influence on energy access. They are some of the few institutions that can fund projects around mini-grid development, solar products for households, and fossil fuel-powered generator systems for health and educational institutions.

As a result of these challenges, very few sizable off-grid companies operate in South Sudan, limiting competition and product and service selection for consumers.

→ Off-grid financing landscape: Limited access to financing for both consumers and off-grid companies

As mentioned above, consumer financing is critical in closing the affordability gap for South Sudanese households to access off-grid energy products and services. However, consumers lack access to financing both through formal financial institutions and the PAYGo model popularised by other off-grid solar companies in East Africa. A negligible minority of households have savings in a formal financial institution due to high poverty levels and an underdeveloped retail banking sector. South Sudan also consistently ranks low in global "access to credit" ratings. Formal financial institutions view consumers as high-risk borrowers due to a lack of systems for capturing consumer credit data and scoring. The PAYGo model implemented by other off-grid companies in East Africa that, has been vital in the uptake of household solar products is also difficult to implement in South Sudan, due to lack of widespread mobile money infrastructure and adoption.

Off-grid companies also have very limited access to working capital and growth capital. Formal financial institutions require collateral conditions for loans that most companies cannot meet. And those who can satisfy collateral requirements are then faced with high-interest rates of up to 30% per year. Foreign investors are also reluctant to provide hard currency financing for off-grid companies due to the high perceived risk of operating in South Sudan and the high exchange rate risk driven by the depreciation of the South Sudanese pound. However, emerging innovative initiatives seek to channel non-concessional finance to support energy access projects. Carbon finance to incentivise a shift from fossil fuel-powered electricity generation, the Peace for Renewable Energy Credits (P-REC) and International Renewable Energy Credits (I-REC) are some examples, although none of these has been demonstrated at scale.

Regarding P-RECs, a renewable project implementer in a fragile, energy-poor country such as South Sudan would obtain P-RECs issued under the international Renewable Energy Credits (I-REC) standard. Subsequently, the project implementer would sell the P-RECs to an impact buyer. For example, in 2020, the International Organization for Migration (IOM) completed the installation of a 700kW solar PV mini-grid to power its humanitarian hub in Malakal. The resulting P-RECS were sold to Block, enabling IOM to finance the electrification of Malakal Teaching Hospital. Result Based Financing (RBF) to accelerate access to energy services, an instrument commonly used in other markets to bridge the affordability gap, is also lacking in South Sudan.

→ Policy and regulations: Lack of enabling environment and tax incentives supporting the off-grid sector

The energy sector's policy and enabling regulatory environment is still in its formative stage, especially for the off-grid sector. No policy or legislative articles directly and explicitly support off-grid energy products. Policy proposals by parliament to establish a South Sudan Rural Electrification Agency (SSREA) and South Sudan Electricity Regulatory Authority (SSERA) have been put forward but are yet to be operationalised. A key constraint is the lack of institutions that can promote a positive regulatory environment and recognise the potential role of off-grid solutions in rural electrification.

There are also no tax incentives to support the growth of the off-grid sector. Like other imported goods in South Sudan, off-grid energy products and solutions attract an import duty, whereas other countries in the East Africa Community have offered import duty exemptions and other tax incentives targeted at the off-grid sector.

Although private sector opportunities in the off-grid market in South Sudan could be substantial due to the large un-electrified population, the lack of an overarching electrification policy and strategy that incorporate off-grid solutions creates uncertainties and heightens the risk for both off-grid companies and their potential investors.

6.2 Recommendations to accelerate the off-grid sector in South Sudan

6.2.1 Demand-side interventions

a. Addressing access and affordability gaps.

Addressing the access and affordability gaps will require various subsidies and incentives. Appropriately designed, targeted, and priced subsidies will reduce the additional cost associated with entering and operating in hard-to-reach markets, including remote areas with sparse populations. Subsidies can also bridge the affordability gap by lowering the upfront costs for end-users. This study finds that many households cannot afford essential off-grid products. Deploying subsidies aligns with the global aspiration of "leaving no one behind" and allows poor and marginalised communities to access modern energy solutions.

This study recommends two types of subsidies:

i) a Result Based Financing (RBF) facility targeting the promotion of quality verified Tier 1 and above off-grid products and

ii) grants awarded competitively.

- The term **"results-based financing"** encompasses various programmes or interventions that offer incentives (monetary and non-monetary) to individuals, institutions or companies only after they have achieved pre-determined results that are verified (Holland & Lee, 2017). For example, between 2014 and 2018, Energizing Development (EnDev) through the SNV Netherlands Organization partnered with 11 solar companies in Tanzania through an RBF mechanism and initially distributed 390,000 pico-solar products in the remote Lake Victoria Zone (SNV Netherlands Organization & SunFunder, 2021). Furthermore, through the RBF mechanism, the solar companies established a presence in the previously unreached region and will continue to provide much-needed off-grid solar products. A similar RBF facility will enable the government and development organisations to provide direction on promoting off-grid products in South Sudan.

- **Grants** can also be used to unlock additional capital creating the needed synergies. In this case, off-grid companies would present proposals to a grant programme describing how their intended projects and the grant financing required. The grant programme would need the SMEs to match the funds requested, e.g., by providing at least 30-40% of the funds. The grant would be distributed based on set milestones as the SME implements the project. For example, the Africa Enterprise Challenge Fund (AECF) implemented the Renewable Energy and Adaptation to Climate Technologies (REACT) in 14 sub-Saharan African countries by offering matching grants to small and medium enterprises to implement their renewable energy projects. Under the REACT-SSA programme, successful investees obtained 60-70% grant funding to distribute solar PV devices for lighting and productive use, construct mini-grids and distribute improved cookstoves (AECF, 2021). Through the Ministry of Energy and Dams, the Government of South Sudan can design such a facility with support from development organisations, including the World Bank, to de-risk off-grid energy companies.

Consumer financing for end users willing to pay for off-grid solar products over extended periods could be channeled through micro-finance institutions in partnership with solar companies. The mechanism could initially target SMEs in urban areas dependent on diesel generators. However, to reach this segment of customers, solar companies will have to offer a range of products, including small and more affordable quality-verified solar products, to attract bottom-of-the-pyramid customers such as traders with no permanent premises. Solar companies are currently focused on installing large systems purchased by NGOs.

b. Leveraging humanitarian presence

Humanitarian activities in South Sudan are funded by donors who provide millions of dollars annually, with a portion going towards purchasing diesel fuel for electricity. Such funds can be provided towards transitioning to solar energy, as was the case in Kenya, where the growth in the solar market was attributed to donor-led interventions. Presently in South Sudan, several non-governmental organisations have installed solar systems in their premises, serving as the largest market for many of the retailers interviewed in the study. Organisations such as UNICEF and UNDP have also installed solar systems

nationwide in schools and healthcare facilities (Lemi & La Belle, 2020).

Refugee contexts in countries such as Jordan have also led to the increased transition to solar energy through donor-led initiatives. Humanitarian agencies can also play a critical role in generating demand for solar systems in South Sudan refugee settlements, where biomass is predominantly used as energy source (Lemi & La Belle, 2020). For example, in 2020, a 700kWp solar PV plant combined with a battery storage system was installed by Scatec Solar at a refugee settlement managed by the International Organization for Migration (IOM) in Malakal (World Bank, 2021).

6.2.2 Supply-side interventions

a. Developing the off-grid products supply chain and product line

The South Sudan off-grid market is dominated by non-specialised vendors and retailers who sell other products, including off-grid products. Most of the products are not quality-verified, nor do they receive any incentives to target end-users who cannot afford a one-time upfront payment. Developing this supply chain will require business support services, including market surveys, procurement support, compliance support, and business planning. Very few off-grid businesses understand the South Sudan market landscape, and those in operation cover small and specific areas. These support tools will cause existing businesses to expand their jurisdiction and product offerings and attract prospective businesses. Nationwide consumer awareness campaigns are done in close collaboration with businesses, and highlighting available off-grid options will complement the business support services. The Government of South Sudan, through the Ministry of Energy and Dams with support from the World Bank, can establish a facility offering these options, complementary to the concessional financing facility proposed above.

The lack of access among social institutions, including those in the education and health sector, provides unique business opportunities. Businesses providing various energy services and products for this segment require support with technical design, feasibility assessments, and access to appropriate financial services.

b. Connecting the financing services with opportunity on the off-grid sector

Predictable and appropriately matched financial enterprise support will provide the much-needed capital to current and prospective businesses operating in South Sudan's off-grid sector. This study finds that access to finance is a pervasive limitation across most businesses in South Sudan. Commercial financial institutions and intermediaries will require highly discounted capital for on-lending to off-grid businesses. Affordable capital from government or development agencies can be blended with non-concessional finance to provide an expanded option of financing solutions to off-grid businesses at affordable rates. The aim of this support is to lower the cost of capital (interest rates and associated costs) while increasing the number of financing actors and the level of financing. These financing options should be provided in local and foreign currency lending as the businesses need.

c. Improve local technical capacity.

Some avenues to build local capacity include training installers or repair technicians, exchanging knowledge through educational programmes to increase local expertise, and partnerships between local and international companies. The value of partnerships with local companies lies in their knowledge of local contexts, such as the maintenance ecosystem already in place. By leveraging the existing market capacity and integrating this into the supply chain, instead of establishing new systems, there is a better chance of market development (Kizilcec & Parikh, 2020).

6.2.3 Enabling environment interventions

a. Supporting the legal, policy, and institutional framework design and development.

The Government of South Sudan should develop an overarching national electrification plan and strategy that will guide public and private sector investments in the off-grid sector. The envisioned role of the private sector should be outlined in this planning process. This should be complemented by strengthening the capacity of the current institutions in the energy sector, the Ministry of Energy and Dams, and SSEC and addressing the institutional gaps, including the lack of a regulatory body.

b. Adoption of quality standards

To ensure the safety and quality of off-grid products, the Government should develop or adopt minimum standards and specifications to address the widespread market spoilage by sub-standard devices, which erodes

consumer confidence. Adopting quality standards would be beneficial in protecting consumers from substandard products and encouraging sales of high-quality, durable products. Countries such as Sierra Leone, Ethiopia, Senegal, Zambia, Zimbabwe, and Uganda have adopted the International Electrotechnical Commission (IEC) standards, which integrated the World Bank Group's Lighting Global quality standards for solar kits in 2021. These standards aimed to increase and maintain quality within the off-grid solar products sector. Alongside quality standards, authorities must build the capacity to implement them by undertaking market surveillance to ensure quality products reach consumers.

c. Removal of import duty and VAT on off-grid solar products

In line with the East Africa Community member states, South Sudan should remove import duty on solar products. Such measures could also result in improved affordability of the end products by households. Tariff rises should also be linked to prevailing exchange rates and inflation levels since solar companies cannot change their prices. Several sub-Saharan African countries provide VAT or import duty exemptions for solar energy kits and components, including Senegal, Mali, Benin, and Liberia, which introduced these measures in 2020. Others, such as Mali, Senegal, Sudan, Liberia, and Togo, have expanded these tax exemptions to include productive use technologies such as solar water pumps.

d. Developing foundational regulations to support mini-grids

Private sector mini-grid developers require guidance on the licensing and permitting processes and the tariff-setting regulations. Alongside the mini-grid regulations is the national electrification strategy which would define the role of mini-grid companies and what areas of the country they should operate.

e. Develop E-waste guidelines

Although the uptake of solar home systems is still nascent within South Sudan, there will be a growing need for waste management and recycling facilities as uptake increases. Given the rise in electronic products sold worldwide, including in the off-grid solar sector, countries are implementing measures to strengthen waste management regulations in response to the e-waste management challenges (Lighting Global et al., 2022). However, few sub-Saharan African countries, including Rwanda, Nigeria, Kenya, and South Africa, have facilities equipped to handle e-waste from off-grid solar, and it is costly to transport waste to these countries (Lighting Global et al., 2022). As such, companies operating in South Sudan's off-grid solar sector must implement plans to handle e-waste, including partnering with other companies in the wider electronic sector.

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Annexes

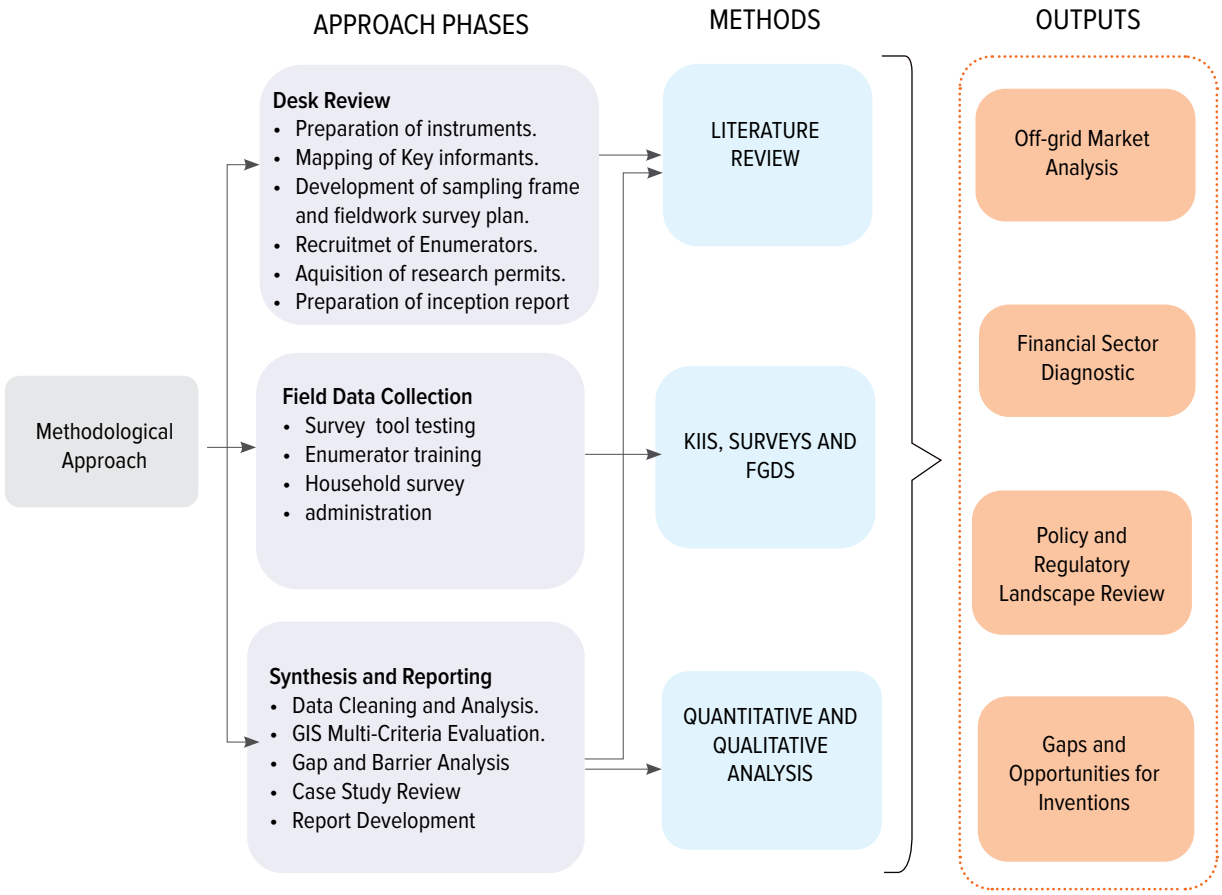
ANNEX1: FIELD DATA COLLECTION PHASE

Approach and Methods

The study employed a three-step approach to execute the four key assignment phases, as captured in Figure 34 below. The diagram also outlines the methods used under the study and the outputs, including the off-grid market analysis, the financial sector diagnostic, the policy and regulatory landscape review and the gaps and opportunities that the World Bank and the transitional government can address.

FIGURE 34

Approach Diagram



Desk Review Phase

The key activities implemented at the desk review phase included preparing survey instruments, finalising the sampling framework for demand-side surveys, mapping and contacting key informants, acquiring research and travel permits, developing, and submitting the inception report, and preparing the fieldwork. We first undertook a literature review to gather information on the demand and supply-side metrics to ground our approach. Some of the sources we interrogated during this phase are captured in Table 13 below.

Table 13: Examples of literature reviewed

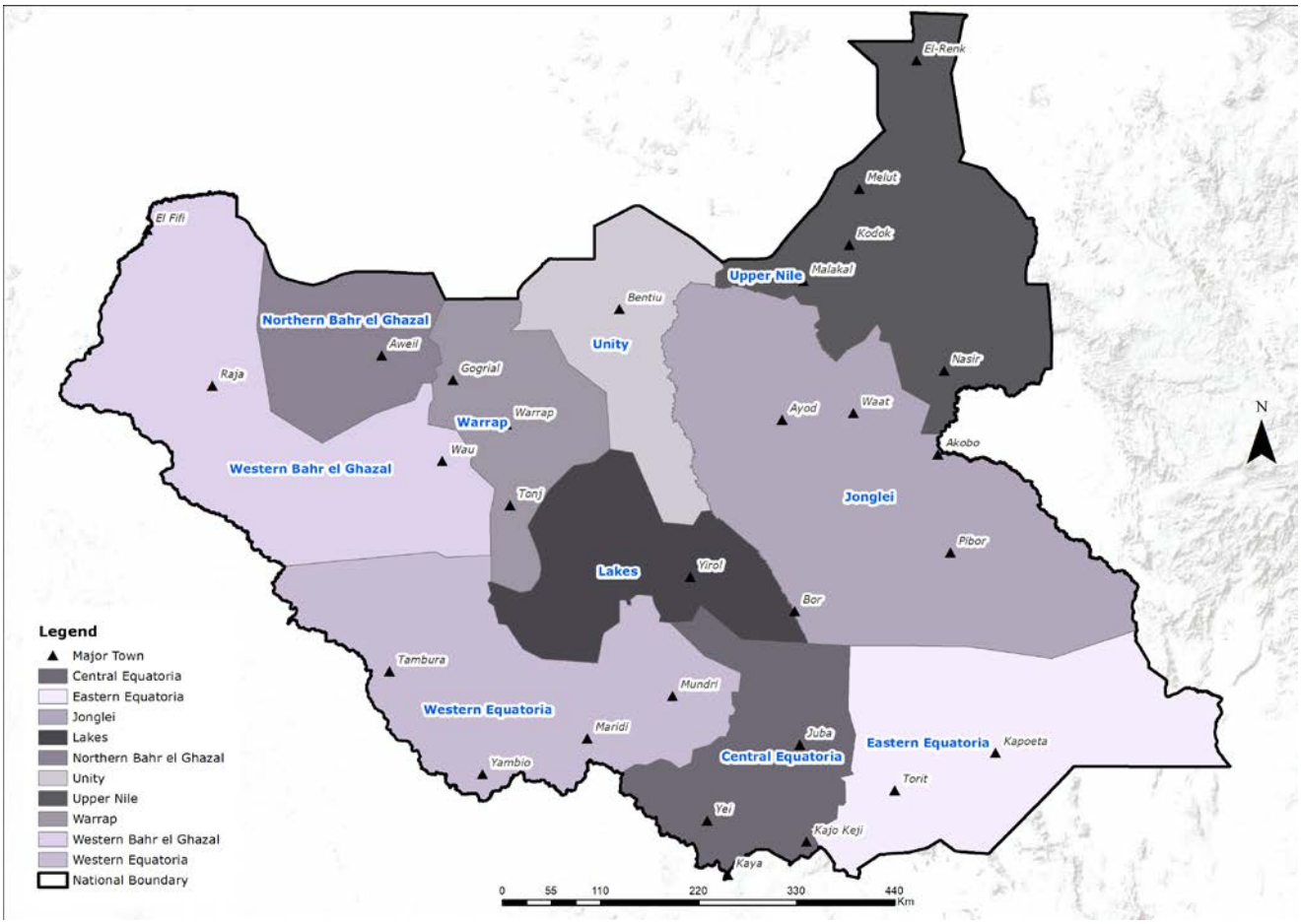
#	Author and Year	Document
1	Africa Infrastructure Country Diagnostic (2011)	South Sudan's Infrastructure: A Continental Perspective
2	South Sudan National Bureau of Statistics (2012)	National Baseline Household Survey 2009 Report
3	Ministry of Energy and Dams (2017)	South Sudan Oil and Power 2017. Power Sector in South Sudan
4	The Sudd Institute (2018)	Transitioning to Renewable Energy: An Analysis of Energy Situation in Juba, South Sudan
5	The World Bank (2021)	Tracking SDG7: The Energy Progress Report 2021
6	Altai Consulting (2014)	South Sudan: Mapping the supply chain for solar lighting product
7	World Bank (2013)	Republic of South Sudan: Electricity Sector Strategy Note
8	D. Mozersky (2018)	South Sudan's Renewable Energy Potential: A Building Block for Peace.
9	International Energy Association (IEA), (2019)	Africa Energy Outlook
10	UNEP (2017)	Atlas of Africa Energy Resources
11	Ladu David Morris Lemi, Michael Carnegie La Belle (2020)	Co-Supplying the National Grid: An assessment of private off-grid electricity generation in Juba South Sudan.
12	African Development Bank (AfDB) (2013)	South Sudan: An Infrastructure Action Plan- A program for sustained strong economic growth.
13	GOSS (2007)	Proposed National Electric Sector Policy
14	GOSS (2011)	South Sudan National Development Plan (2013-2016)
15	Ministry of Energy and Dams (2013)	Rapid Situation Assessment and Gap Analysis Report
16	GOSS (2015)	National Electricity Sector Bill
17	USIP (2018)	South Sudan's Renewable Energy Potential – A Building Block for Peace
18	GOGLA (2021)	Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data.

Developing the Sampling Framework

As illustrated in the diagram below, South Sudan is divided into 10 states, two administrative areas, and one area with special administrative status. Recognising the dynamic security and accessibility challenges in many parts of the country, we conducted a demand-side analysis across institutions and households in all 10 states in South Sudan where practical and safe.

FIGURE 35

Map of States and Administrative Units in South Sudan.



Data was collected using three main methods: household surveys, institutional surveys, and focus group discussions.

a. Household Surveys

The study was a nationally representative survey. Based on recommendations from the World Bank team, the household survey was stratified along urban-rural lines. Rural populations in South Sudan are assumed to be homogenous in terms of using off-grid solar products. Consequently, there is a preference to oversample households in urban areas that may have more varied preferences when it comes to using off-grid products. A three-stage sample selection process, elaborated below, was adopted to guide the sampling for the household surveys.

Household Sample Size Calculation

The household sample size was determined using Cochran's formula with a finite population correction factor (FPC). We elected to use this sample calculation formula since sampling is without replacement. It is important to note that since the calculated sample size is already less than 5% of the entire population, the FPC does not make much difference (Kotrlik & Higgins, 2001).

$$n = \left\{ \frac{z\frac{a^2}{2}\, p(1-p)}{e^2} * N \Big/ \left(\frac{z\frac{a^2}{2}\, p(1-p)}{e^2} + (N-1) \right) \right\} kf$$

Table 14: Formula and Assumptions in Calculating the Sample Size

Symbol	Value	Description
Z	1.96	The critical value of the normal distribution at $\frac{a}{2}$. At a 95% level of confidence, **a = 0.05** and the critical value is 1.96.
p	0.5	Conservative prevalence of the indicator of interest
	5%	The margin of error. 5% is standard.
F	1.10	Factor accounting for non-response (assume 10%)
K	1.5	Design effect. 1.5 is standard.
N	varies	The population of rural and urban South Sudan
n		Sample size

As of 2020, South Sudan's population was estimated at 11,193,729, with 20.2% of the population in urban areas and 80% in rural areas **(United Nations Population Fund, 2022**). Due to the need for oversampling in urban areas, the sample size for rural and urban areas was calculated separately. The formula yielded a sample size of 634 households in each locality, totaling 1268 households. The sample size was later revised to capture the diversity of the urban areas at a higher precision by splitting it in a 60:40 ratio in favour of urban areas. This gave a final sample size of 507 rural and 761 urban households.

First stage Sample Selection

The survey used the sampling frame from South Sudan's National Bureau of Statistics (NBS). Due to the ongoing conflicts and seasonal floods in South Sudan, the sampling frame was very outdated. The Poverty Practice team provided 6 rural and 6 urban PSUs for each of the 10 states. Only 59 urban and 27 rural EAs were accessible at the beginning of the data collection exercise.

Second stage Sample Selection

Enumerators selected the households during fieldwork using the random walk technique and SW Maps. The SW Maps indicated the PSU location and boundary. The random- walk is a probabilistic sampling method where a field supervisor allocates enumerators' specific starting points from where they can proceed to interview every 5th household along a road or a path.

b. Institutional Surveys Sample Design

Preliminary research indicates that there are about 8,000 primary schools in South Sudan and 120 secondary schools (United Nations Population Fund, 2022). Datasets from the Ministry of Health (MoH) indicate that there were about 1,877 health facilities across the country in 2018, as outlined in the table below. There are also several Non-Governmental Organisations (NGOs) working in South Sudan and government administrative offices located in the different states and counties.

Table 17: Number of Health Facilities in South Sudan as of 2018

No.	State	Number of Health Facilities
1	Central Equatorial	374
2	Eastern Equatorial	293
3	Jonglei	159
4	Lakes	118
5	Northern Bahr el Ghazal	135
6	Unity	124
7	Upper Nile	153
8	Warrap	153
9	Western Bahr el Ghazal	137
10	Western Equatorial	231
11	Total	1877

The survey was administered to a mix of 280 health facilities, primary schools, secondary schools, administrative government units, and non-governmental and humanitarian offices to establish their electrification status and future needs. Interviews were conducted in institutions PSU within 5km of the PSUs. The focus of this survey was to establish the geographic location of these institutions, current electricity source (if any), and estimated demand (kW) and electricity consumption (kWh). The questionnaire included questions on the type of appliances, their capacity and the duration of use in a day, and the quality of the electricity (e.g., low and high voltage fluctuations and interruptions).

c. Focused Group Discussions Sample Design

We also conducted one focused group discussion in every state to supplement the information obtained from the household and institutional surveys.

The FGDs were conducted alongside the household survey. One field supervisor was tasked with facilitation and another notetaking to maintain efficiency. All FGD participants were required to provide consent to participate in the FGD. The teams worked to have an equal mix of female and male participants and young and old respondents at each FGD to capture views across different strata in the community.

Preparation of survey instruments and training manuals

We developed semi-structured, qualitative KII and FGD guides and structured, quantitative household and institutional survey tools during the desk review phase of the assessment. The questionnaires were coded on SurveyCTO and tested to ensure that skip-logic patterns were consistent. In addition, we developed key informant interview guide templates for the different groups of key informants, as outlined above. These templates were tailored to each Key Informant Interviewee. An FGD guide was also developed and shared with the project team to ensure all relevant questions had been captured.

Some of the themes that were captured in the household and institutional surveys are exemplified in Table 15 below.

Table 15: Example of thematic areas for the survey instruments design

#	Theme	Issues
1	Household dynamics	Number of members, income-generating activities, level of income, standards of living (through proxy indicators, e.g., type of house, phones, land tenure, bicycles, motorbikes, vehicles), technical/educational qualification, access to potable water, access to finance
2	Energy sources and use	Types and sources of household/institutional energy for electricity, lighting, cooking operating equipment, the quantity of household energy consumption, estimated cost of household/institutional energy, access to grid electricity, and awareness of off-grid energy options (solar products, brands, payment models)
3	Livelihood regimes /Type of Institutions	Specific to the institutions and home enterprises depending on their economic activity, e.g., Agriculture, fisheries, business/commerce, employment, remittances, mineral extraction, other (charcoal production, fisheries, beekeeping etc.)
4	Socio-economic grouping	Participation in SACCOs, youth groups, women groups, farmer groups, business groups
5	Willingness to Pay (WTP) & Ability to Pay (ATP) for grid connection and off-grid energy solutions (solar products and appliances for lighting, entertainment, and productive use)	Respondents were randomly assigned a device and its average market price for solar products. To assess willingness to pay for grid connection or a solar product, they were asked if they would pay the full price upfront, full price in instalments or 50% of the price upfront. With this approach, we can study: i) payment modality (upfront or instalments). ii) how much flexibility of payment they are looking for.

The preparation of instruments took place alongside the preparation of training manuals for enumerators and field supervisors. The manuals were used to guide the training of the two categories of field agents. The manuals also elaborated on the key activities of the supervisors and enumerators, as outlined below.

FIGURE 36
Training Manual Contents

Field Supervisors

- Logistical Considerations including processing of enumerators.
- How to participate in protocal visits and community engagement.
- How to supervise and cordinate enumerators while in the field.
- Quality control.
- Emergency response measures and field security protocals.

Enumerators

- Assignment description and roles and responsibilities.
- Directions on how to use data collection software.
- Data colection etiquette and protocal requirements while in the field.
- Emergency reponse measures.
- Quetionaires with elaborations on all questions with specific emphasis on difficult or sensitive questions.
- Pictorial ilustration as relevant.

Mapping and Contacting Key Informant Interviewees

Data collected from key informants is integral for the supply-side market assessment, review of the policy landscape, development of the financial sector diagnostic, and validation of the identified gaps and opportunities. Mapping of the first key informants was done through a desk review. More informants were identified via snowballing approach as the interviews were conducted.

The KIIs were conducted both physically and online using platforms like Zoom and Microsoft Teams. Physical KIIs were conducted with some government entities and the South Sudan Electricity Commission. Some of the key informants interviewed under the assessment are outlined in Table 16 below.

Table 16: List of key informant interviewees

Government Entities and Parastatals	
1	South Sudan Electricity Corporation (SSEC)
2	South Sudan Electricity Corporation (SSEC)- Engineering, Finance and Legal departments
3	Yei County executive officer for electricity
4	Representatives from the Ministry of Finance
5	Ministry of Energy and Dams
6	Ministry of Finance
Non-Governmental organizations and DFIs	
7	Energy for Peace Partners
8	The African Development Bank (AfDB)
9	ElectriFI (USAID & EU funded)
Off-grid Solar Companies and associations	
10	Africa Mini-grid Developers Association
11	NRECA International
12	Aptech Africa Limited
13	Sungate Solar
14	PowerGen
15	Go Solar Systems Limited
16	Davis and Shirtliff South Sudan
17	Bomatek Electric Ltd
18	Chescohitech
Financial institutions	
19	Equity Bank South Sudan
20	Ajohdit Micro-Finance Institution
21	Petro Maduk Deng (South Sudan Financial Expert)

The information gathered through this method is logged onto an online data reporting sheet and will be analysed using NVIVO along the general themes of the assignment (assessing demand, supply, the enabling environment and the barriers/opportunities in the off-grid sector)

Acquisition of Research and Travel Permits

To prepare for fieldwork, the firm secured the necessary approvals from the Ministry of Health, Research, Ethics Review Board, valid from 27th May 2022, for eight months. With support from the World Bank Group, the consultants also acquired the sampling frame from the National Bureau of Statistics.

The desk review phase concluded with field visit preparations. This involved mobilising the enumerators and field supervisors, making logistical and security arrangements for travelling to the selected areas, contacting and scheduling interviews with key informants, and continuously refining the survey tools.

Field Data Collection Phase

Training of Enumerators and Field Supervisors.

a. Theory session

Between Aug 4 - 6th 2022, in Juba, South Sudan, the Sudd Institute, in collaboration with the EED team, trained 25 enumerators. The training took the field teams through the survey tools and how to use the Survey CTO application. Each participant was given a tablet with a preloaded questionnaire. The field team were also taken through the process of how to use SW maps to locate an enumeration area and a randomly selected household. In addition, the enumerators were taken through an overview of the power sector in South Sudan and keywords used in the research instruments.

b. Role plays

After the theory session, the participants were divided into pairs. With one participant acting as the numerator and the other the respondent, they went through the questionnaire multiple times. The EDD and Sudd team observed the process taking note if:

- the enumerators were able to introduce the purpose of the study,
- the enumerators were familiar with the questions and how confident they were in administering the interview,
- the enumerators could administer the survey within the expected time without rushing the interview.

c. Field Pre-test

After the role plays, the enumerators were sent to interview households in nearby locations in teams of two. The logistics of the pre-test were designed to save time and minimise transportation costs. Each team interviewed at least 2 households. The feedback was used by EED and Sudd team to update the questionnaires.

ANNEX 2: ESTIMATING ELECTRIFICATION INVESTMENT NEEDS FOR INSTITUTIONS

Characteristics of health institutions

Datasets from the Ministry of Health (MoH) indicate that there were about 1,877 health facilities across the country in 2018, as outlined in the table below.

Table 17: Number of Health Facilities in South Sudan as of 2018

No.	State	Number of Health Facilities
1	Central Equatorial	374
2	Eastern Equatorial	293
3	Jonglei	159
4	Lakes	118
5	Northern Bahr el Ghazal	135
6	Unity	124
7	Upper Nile	153
8	Warrap	153
9	Western Bahr el Ghazal	137
10	Western Equatorial	231
11	Total	1877

The health facilities interviewed can be characterised based on:

i) **Level of Facility:** A majority, 87%, were health centres, 8% were hospitals, and 5% were dispensaries

ii) **Ownership:** where 57% were public, private (37%), a religious group affiliated (2%) and NGO affiliated institutions (5%)

On average, the institutions serve about 51 patients a day while operating for about 16 hours daily.

Characteristics of Educational Institutions

Education institutions in South Sudan can be classified as primary, secondary, technical, or vocational, and university. Preliminary research indicates that there are about 8,000 primary schools in South Sudan and 120 secondary schools (GPE, 2021). Primary education institutions constitute the highest number of educational institutions at 64.03%, as seen below.

Table 18: Types of Education Institutions in South Sudan

Type of institution	Percentage of education institutions		
	Urban	Rural	Total
Primary	57.43	88.74	64.03
Secondary	23.96	11.26	21.28
Technical/Vocational	9.48	0	7.48
University	4.98	0	3.93
Other	4.16	0	3.28

Education institutions in South Sudan employ 23 staff who serve an average of 687 students. They operate for an average period of 8 hours for in-school instruction but are also often used for social and community gatherings.

Estimating the electrification needs for health facilities

To provide a high-level analysis of the energy requirements for a health facility in South Sudan, the following specific data obtained from the survey is used. First, the powering health tool developed by the United States Agency for International Development (USAID) estimates the electrification requirements for each class of health facilities (USAID, 2023). This free online tool can build estimates for electrical power requirements for facilities lacking power or with a partial power supply from the grid. This tool has been integrated with HOMER and returns the optimal combination of power supply options, particularly grid electricity, solar PV, diesel generators, and batteries (USAID, 2023).

The objective of the analysis was to provide an alternative power source to supply the loads available for each health facility. A load profile and estimation of the energy consumption per day is required to effectively do this. The following steps were used to generate the load profile, and the estimates of the daily loads.

- The powering health tool is used to calculate the selection of the type of load that can accurately represent the class of the health facility for which cost estimation is intended.

- Four classes of facilities are covered by the tool – and these include
  - (a) a rural dispensary with up to emergency beds,
  - (b) a small inpatient clinic,
  - (c) a rural hospital with up to 50-bed spaces, and
  - (d) a district or referral hospital which is fully equipped and has up to 140-bed capacity.
- These classes are matched up with the present classes of surveyed health facilities – namely dispensaries, health centres and hospitals.

Table 19: Matching up health facilities

Existing /Survey Category	Designated level of the facility using Powering Health Tool
Dispensary (PHCU)	Rural dispensary
Health Centre (PHCC)	Small inpatient clinic
Hospital to include (county, state, and teaching hospitals)	Rural hospital
	District / referral hospitals

The estimated costs of the system were obtained from several sources, including the websites of common brands.

Source: Shutterstock

Table 20: Balance of system estimates

Balance of system	Cost (USD)
Solar photovoltaics (PV) panels /kW (Center for Alternative Technologies, 2023a)	700 /kW
Converter /kW (Center for Alternative Technologies, 2023b)	400 /kW
Battery energy storage/kWh (Center for Alternative Technologies, 2023b)	625 /kWh
Back up supply Balance of system	Cost (USD)
Diesel generator (Perkins, 2023)	250 /kVA
Cost of fuel (WFP, 2022)	2.00 /liter
Cost of the grid connection	
Simple tariff applied	0.43 /kWh

The load estimates for the health facilities are obtained using the online Homer Powering Health tool. This is input into the Homer tool together with the equipment cost and the optimisation conducted to determine the combination that provides the least energy cost. Further assumptions made include the cost of maintenance for solar panels, battery storage system, the converter system. A default discount rate of 8% and inflation of 2% are also applied in the Homer tool.

The following assumptions on the load profile are based on the selected type of health facility and the variables obtained from the availability of electric grid or not.

1. The dispensary assumes a residential load profile with an estimated 5.63kWh average daily load.
2. A small inpatient clinic assumes a residential profile with an estimated 13.9kWh.
3. The small rural hospital assumes a commercial load profile with an estimated daily energy consumption of 37kWhs.
4. The hospital is assumed to take a commercial load profile with two different loads- (a) 361.1kWh.

Table 21: Balance systems maintenance costs

#	Balance of system maintenance costs	Cost (USD)
	Battery maintenance	10.00/yr.
	Converter maintenance	0.00
	Generator maintenance	0.03/hr
	Solar PV maintenance	10.00/yr.

The results are simulated for three categories of health institutions i) dispensary, ii) health centre, iii) hospital.

Table 22: Estimated cost estimates for electrifying health facilities, schools and government offices through a diesel-only option

#	Facility type	Number of facilities	Total diesel only initial cost (US$)	Total annual maintenance costs/year (US$)
	County facility	23	33,925.00	380,374.00
	State/teaching/referral hospital	25	362,500.00	3,858,975.00
	PHCC	306	221,850.00	2,244,816.00
	PHCU	1079	323,700.00	3,270,449.00
	Total (US$)	1433	941,975.00	9,754,614.00

Table 23: Estimated cost estimates for electrifying schools through a diesel-only option

#	Type of facility	Number of facilities	Initial cost (US$)	Operation and maintenance cost (US$)
1	Primary schools	5,966	1,789,800.00	19,640,072.00
2	Secondary schools	412	463,500.00	5,178,428.00
	Total (US$)	6,378	2,253,300.00	24,818,500.00

Table 24: Estimated cost estimates for electrifying government offices through a diesel-only option

#	Type of facility	Number of facilities	Initial cost (US$)	Operation and maintenance cost (US$)
1	National offices	370	1,942,500.00	12,328,770.00
2	State offices	100	525,000.00	3,332,100.00
3	County offices	462	2,425,500.00	15,394,302.00
	Total (US$)	932	4,893,000.00	31,055,172.00

Table 25: HOMER Assumptions for Health Facilities

#	variable	Value
Grid-connected primary schools		
	Average load ((IRR=24%, ROI=20%, PB=4.0years)	7kWh
	Basileine NPC	$14203
	Lowest cost	$6,243
	Initial capital	$0.00, $3,894
	O&M	$1,099 and $181..7 per year
	LCOE	$0.430, $0.162
	PV	2.44kW
	Bess system	3kWh
	Converter system	0.775kW
	Total number of primary schools	5,9666
Off-grid primary schools		
	NPC Basileine	$42,852
	NPC Lowest cost	$8,031
	Initial capital	$300.00, $5,193
	O&M	3,292 and 219.55 per year
	LCOE	$1.30, $0.243
	PV	(3..72kW),
	Bess system	3kWh
	Converter system	1.04
	Generator	1.20kVA

#	variable	Value
Grid-connected secondary school		
	IRR	26%
	ROI	21%
	Payback	3.8years
	NPC Basileine	$56,608
	NPC Lowest cost	$24,131
	Initial capital	$0.00, $14,909
	O&M	$4,379 and $713.33 per year
	LCOE	$0.43, $0.156
	PV	(9.72kW),
	Bess system	11kWh
	Converter system	3.08
Off-grid secondary school		
	Average load (IRR =62%, ROI= 58%, 1.6 years)	27.9kWh
	NPC Basileine	$163,611
	NPC Lowest cost	$31,842
	Initial capital	$1,125, $20,584
	O&M	12,569 and 870.82per year
	LCOE	$1.24, $0.242
	PV	14.80kW
	Bess system	12kWh
	Converter system	4.0kW
	Generator	4.50kVA

Table 26: Homer Assumptions for Educational Facilities

#	variable	Value
Grid-connected primary schools		
	Average load ((IRR=24%, ROI=20%, PB=4.0years)	7kWh
	Basileine NPC	$14203
	Lowest cost	$6,243
	Initial capital	$0.00, $3,894
	O&M	$1,099 and $181.7 per year
	LCOE	$0.430, $0.162
	PV	2.44kW
	Bess system	3kWh
	Converter system	0.775kW
	Total number of primary schools	5,9666
Off-grid primary schools		
	NPC Basileine	$42,852
	NPC Lowest cost	$8,031
	Initial capital	$300.00, $5,193
	O&M	3,292 and 219.55 per year
	LCOE	$1.30, $0.243
	PV	(3.72kW),
	Bess system	3kWh

#	variable	Value
	Converter system	1.04
	Generator	1.20kVA
Grid-connected secondary school		
	IRR	26%
	ROI	21%
	Payback	3.8years
	NPC Basileine	$56,608
	NPC Lowest cost	$24,131
	Initial capital	$0.00, $14,909
	O&M	$4,379 and $713.33 per year
	LCOE	$0.43, $0.156
	PV	(9.72kW),
	Bess system	11kWh
	Converter system	3.08
Off-grid secondary school		
	Average load (IRR =62%, ROI= 58%, 1.6 years)	27.9kWh
	NPC Basileine	$163,611
	NPC Lowest cost	$31,842
	Initial capital	$1,125, $20,584
	O&M	12,569 and 870.82per year
	LCOE	$1.24, $0.242
	PV	14.80kW
	Bess system	12kWh
	Converter system	4.0kW
	Generator	4.50kVA

ANNEX 3: BANKS IN SOUTH SUDAN

Table 27: Banks in South Sudan

Start Year	Banks
2006	Ivory Bank KCB Bank South Sudan Limited Nile Commercial Bank
2008	Buffalo Commercial Bank
2009	Commercial Bank of Ethiopia Equity Bank South Sudan Limited
2011	Charter One Bank South Sudan Commercial Bank Mountains Trade and Development Bank Qatar National Bank
2012	African National Bank Stanbic Bank Kenya Limited Liberty Commercial Bank International Commercial Bank Eden Commercial Bank Afriland First Bank
2013	Cooperative Bank of South Sudan Royal Express Bank Regent African Bank Phoenix Commercial Bank People's Bank Southern Rock Bank Opportunity Bank National Credit Bank Kush Bank PLC Ecobank South Sudan Ltd
2015	Alpha Commercial Bank Ebony National Bank
2016	St Theresa Rural Development Bank
In Licensing process	Agricultural Bank

ANNEX 4: OFF-GRID COMPANIES OPERATING IN SOUTH SUDAN

Table 28: Off-Grid Solar Companies operating in South Sudan

Company	Local/ Regional/ International	Operational History	Size of Enterprise	Products Offered	Services Offered	Target Market
SunGate Solar	Local	• Registered in South Sudan in 2015 as a commercial, for-profit company, with offices in Wau, Juba and Awei. • It is South Sudanese owned and operated and receives financial and management support from SunGate Solar Holdings LLC based in the USA.	• 30 employees. • Sold over 110 kW of solar power. • Serving more than 2,000 customers including commercial institutions. • By 2017, they provided solar solutions to over 25 large commercial systems. • The electricity generated through their solutions has supported over 13,000 people.	• Solar home systems, solar lanterns, large solar PV commercial systems, solar street lighting. • SunGate also develops microgrids to deliver reliable electricity. • Other offerings include electric cooking, solar streetlights, and data backups.	Comprehensive energy needs assessment, design, installation, maintenance, and repair.	• Households, businesses, commercial institutions such as universities and hospitals, NGOs such as UN and Red Cross. • KII respondents indicated that 50% market is NGOs and the other 50% is small businesses. • The largest market is in Juba state.
Bomatech Electric	Local	Incorporated in South Sudan in June 2012 and are based in Juba, from where they supply products across the country.		• Quality-verified batteries, solar panels, and inverters from the following manufacturers: Batteries: Deka, Rolls Solar Panels: Suntech, AFR Inverters: Magnum, Growatt, Fronius. • Procure supplies from Arizona from a supplier called African Energy.	Offer 1-year warranties for their products during which they offer after-sales services. In case a project is too far, the client facilitates the transport costs.	• Households, NGOs, health facilities, schools, and businesses, including telecommunication companies. • Majority of their clients are health facilities.
Zetin Solar and Investment Co. Ltd.	Local	• Founded in Juba, South Sudan to promote renewable energy. • Offices located in Juba, South Sudan; Kampala, Uganda; Nairobi, Kenya and Berlin, Germany.		• Supply PV systems for autonomous power generation for on and off-grid applications. • Provide high-quality products made in Germany and Europe. • Supply solar devices including solar panels, inverters, solar batteries and more.	Complete assessments, design appropriate solar systems, supporting consumers to obtain financing options for the solar systems, service, and installation of PV systems.	

Company	Local/ Regional/ International	Operational History	Size of Enterprise	Products Offered	Services Offered	Target Market
Aptech Africa Limited	Regional	• Founded in 2011 for solar energy and water pumping solutions in Africa. • Is an Engineering, Procurement and Construction (EPC) company. • Offices located in South Sudan, Uganda (head office), Central African Republic, Sierra Leone, Niger, and Liberia.		Solar lanterns, solar home systems, batteries and solar panels, and water pumps.	• Complete assessments, design, supply, installation and after-sales services. • Provide warranties depending on the type of product, with the minimum duration being 1 year, which covers after-sales services during the warranty period.	NGOs and UN agencies, water companies, households
Go Solar Systems Limited	Regional	Founded in 2003 as a Kenyan solar company offering a wide range of solar solutions.	Completed over 3,000 residential and commercial installations. They have also installed over 1MW systems.	• Solar panels, inverters, solar batteries, charge controllers, solar LEDs, solar water pumps, solar water heaters, and power backup systems. • -They offer a variety of packages for solar home systems ranging from USD 400 (240W) to USD 2,260 (2.0kva).	• Consultation to identify the optimum solution, installation of the solar system, and annual maintenance. • Solutions offered include solar off-grid, solar hybrid, and solar grid-tie.	Households, businesses, and other commercial institutions
Davis and Shirtliff	Regional	• Founded in 1946 as a Kenyan company. • Branches located in Kenya, Uganda, Tanzania, Zambia, Rwanda, South Sudan, DRC, Zimbabwe, and a partnership in Ethiopia.	• Over 900 highly trained and professional staff and its fleet of distribution trucks. • The headquarters in Nairobi covers an area of 10,000m2 with warehouse, manufacturing, training, and administrative facilities.	Solar water pumps, solar irrigation systems, swimming pools and power back-ups, street lighting, solar home systems and solar water heaters.	Offer warranties for the products and provide after-sales services such as replacement, repairs, and maintenance during the duration of the warranty.	• NGOs and government but the KII respondent cited that they do not engage a lot with the government because of payment issues. • Others include stockists and borehole drillers. • Their largest market is the Central Equitoria state.
Chesco hi-tech	Regional	• Founded in 2011 and opened its first branch in Asmara, Eritrea. • Branches located in South Sudan, Uganda, and Dubai. • In South Sudan, they have shops in Yei, Wau, Juba and Malakal.		• -Specialise in large solar home systems with a minimum capacity of 600W onwards. • The main brand of solar panels, batteries and inverters sold is MaxSolar • Their products are quality verified and they offer installation services as well.	Offer engineering, procurement, construction, operation, and maintenance services for utility-scale solar power projects.	• Main customers are NGOs, institutions, businesses, • However, they also sell to individuals. • Their largest market is in Juba.

Company	Local/ Regional/ International	Operational History	Size of Enterprise	Products Offered	Services Offered	Target Market
PowerGen	Regional	• Founded in 2011 in Nairobi, Kenya as an installer of off-grid power systems. • Offices located in Kenya, Tanzania, Sierra Leone, and Nigeria.	Has over 150 full-time employees and operations in four countries.		Offer consulting, engineering, procurement and construction, logistics, operations and maintenance, and financing for commercial and industrial solar projects, as well as micro-grid development.	Businesses, industries, and households.
Solar World	Regional	• Founded in 2003 providing renewable energy solutions throughout east and central Africa. • Offices are in Nairobi, Kenya.		Supplier of solar panels ranging from 5 watts to 300 watts. They offer mono-crystalline and poly-crystalline solar panels. They also supply solar water heaters and power backup systems.	• Offer installation services for solar panels, water heaters and power backup systems. • An affiliate company, Water Resources International, offers water drilling services.	Commercial businesses and households.
OFGEN Africa	Regional	• Founded in 2014. • Offices located in Nairobi, Kenya; Kampala, Uganda; Kigali, Rwanda; Juba, South Sudan; and Mogadishu, Somalia.	Have an installed PV capacity of 6.2MWp, 9.3MWh of battery energy under management and have installed projects in over 24 sites across Africa. They have a further 15MW of solar capacity under development across Eastern Africa.	Supplier of solar products which they obtain from manufacturers such as Jinko Solar, Trina Solar, JA Solar, Canadian Solar, Tesvolt, Caracal Energy, and Solar World among others.	Provide services covering the solar project lifecycle including project development, financing, monitoring, operation, and maintenance of solar power plants.	Commercial businesses including hotels, universities, and manufacturers.
Equator Energy	Regional	• It is headquartered in Nairobi, Kenya. • Have regional staff in Kenya, Uganda, South Sudan, Somalia, and Zimbabwe	The team consists of over 40 installers with experience in ground and roof-mounted solar systems.	Deliver solar power plants to customers at zero up-front costs, covering all costs from planning to operation.	• Installs and leases solar electric systems. • Services offered include solar audits, designing the solar power system, obtaining permits and licences, installation and commissioning of the system, and monitoring and maintenance.	Industries including manufacturing plants and flower farms, and institutions including hotels and universities.
Scatec Solar	International	• Founded in 2007 in Oslo, Norway as an integrated independent solar power producer. • They develop, build, own, operate and maintain solar power plants.	Has an installation capacity of more than 1.6GW across 4 continents, with an additional 0.3 GW under construction.	Sell power under long-term power purchase agreements (PPAs).	• Services offered include project development, structuring and financing, engineering, procurement and construction, maintenance and repair, and asset management.	

Company	Local/ Regional/ International	Operational History	Size of Enterprise	Products Offered	Services Offered	Target Market
Sunshine Solar	International	Founded in 2004 as an independent UK-based importer of renewable energy products.		• Sell solar panels, solar power kits, power inverters, batteries and chargers, solar lighting kits, and low-energy lighting products. • Solar lighting kits comprise solar panel, charge regulator, LED light unit, lead acid battery, programmable 7-day digital timer, extension cable, and solar panel fixing kit.		
D.Light	International	Founded in the USA in 2006 with the first commercial solar product being sold in the market in 2008.	Sold over 25 million products which have impacted over 125 million people worldwide	• Solar home systems comprise solar panels, mobile-charging battery packs, solar LED bulbs, light switches, torches, and FM radio. • Also offer solar lanterns, portable chargers, and solar power systems.		
Eight19	International	• Was a UK-based solar energy company which developed and manufactured low-cost plastic solar cells for high-growth volume markets. • They launched the IndiGo pay-as-you-go solar project in the Nimule region of South Sudan. • The company is currently closed.[139]	Eight19 deployed around 1000 solar system units to the Nimule region.	• Offered an organic photovoltaic (OPV) technology for solar home systems. • Organic solar technology was based on carbon-based materials, unlike traditional ones which use silicon. • The IndiGo units consisted of a battery, a solar panel, lights, and a phone charging device.		Households and businesses.

ANNEX 5: PRIVATELY OWNED/OPERATED MICRO AND MINI-GRIDS IN SOUTH SUDAN

Table 29: Privately owned/operated micro and mini-grids in South Sudan

Developer	Size of system	Client	Type of end users
Scatec Solar in partnership with Kube Energy(Hankins, 2019)	Solar hybrid plant comprising of a Solar PV capacity: 700kWp and battery energy storage system: 1,368-kWh battery energy storage system.	International Organization for Migration (IOM)	Households
Scatec solar/Kube Energy (Hankins, 2019)	>1MW	UNMISS	
Equator Energy (Hankins, 2019)	230kW	Acacia Camp	
	120Kw solar-diesel hybrid plant	Acacia Village Hotel	
	160kW + 230 kWh off-grid	WLC, logistics base	
	120kW + 240 kWh off-grid	ETC, camp	
	120kW + 200 kWh off-grid	VSS, office and camp	
	140kW	Yambio	
	150kW	Lologo Juba	
Ofgen	Solar PV capacity: 340kWp Battery energy storage solution: 715kWh	UAP Juba	
Sungate Solar/ PowerGen	Microgrid Solar array: 55kWp Battery storage: 84kWh Diesel genset: 66kVA		Small businesses Institutions such as pharmacies, health clinics,
Trinity Energy	TBC		
Aptech Africa	34kW solar PV micro grid	UNDP the ministry of local government and law enforcement in Malakal	Government institution

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