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From Subsidy to Sustainability:

Diagnostic Review of Sudan's Electricity Sector

Final Report

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Abbreviations

BAU	Business as Usual
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CBoS	Central Bank of Sudan
DIU	Dam Implementation Unit
DO	Diesel Oil
EAPP	Eastern Africa Power Pool
ERA	Electricity Regulatory Authority
ESMAP	Energy Sector Management Assistance Program
GDP	Gross Domestic Product
GIS	Geographic Information System
GoS	Government of Sudan
HCGO	Heavy Coked Gas Oil
HFO	Heavy Fuel Oil
HV	High Voltage
IFI	International Financial Institution
IMF	International Monetary Fund
IPP	Independent Power Producer
LCP	Least-cost Plan
LDO	Light Diesel Oil
LFO	Light Fuel Oil
MoFEP	Ministry of Finance and Economic Planning
MoWRIE	Ministry of Water Resources, Irrigation, and Electricity
MTF	Multitier Framework
MV	Medium Voltage
NEC	National Electricity Corporation
NHHBPS	National Household Budget and Poverty Survey
NPV	Net Present Value
OECD	Organization for Economic Co-operation and Development
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PPP Act	Public-Private Partnership Act
PSIA	Poverty and Social Impact Assessment
RISE	Regulatory Indicators for Sustainable Energy
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SC	Sponge Coke
SE4ALL	Sustainable Energy for All
SEDC	Sudanese Electricity Distribution Company
SEHC	Sudanese Electricity Holding Company
SETCO	Sudanese Electricity Transmission Company
SHGC	Sudanese Hydropower Generation Company

SHS	Solar Home System
SIP	Social Initiative Program
STPG	Sudanese Thermal Power Generation
SUBSIM	Subsidies Simulation
UNDESA	United Nations Department of Economic and Social Affairs
UNDP-GEF	United Nations Development Programme-Global Environmental Finance

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Executive Summary

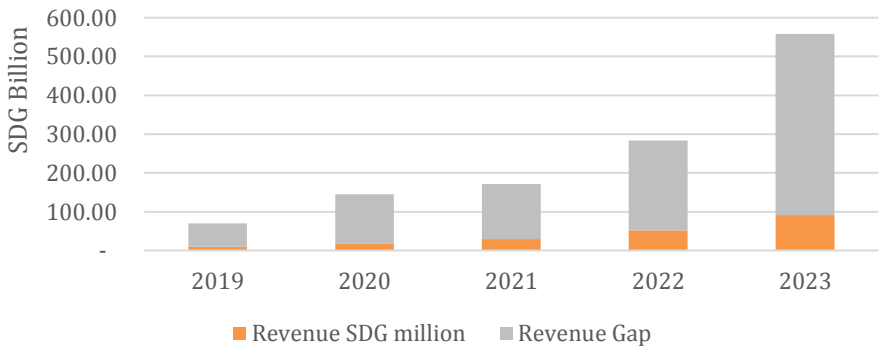
Sudan's electricity sector is operating efficiently from a technical standpoint, compared to other countries in the region. Sudan has one of the largest power systems in Sub-Saharan Africa, with 3,500 MW of electricity generation capacity from hydro and thermal sources. System loss is relatively low for the region, and bill collection is almost universal, making Sudan one of the top performers in Sub-Saharan Africa in that category. Cost of service, which is estimated at US¢20 per kWh, is close to the regional average. However, the sector does face many of the operational challenges common to countries in the region with regard to management and finance. These include a low electricity access rate of 32 percent and load shedding during summer peak hours.

The most urgent issue facing the sector is financial sustainability. Sudan's electricity tariff is the lowest in Sub-Saharan Africa, with a rate under US¢1 per kWh. Driven by the low tariff, electricity demand has grown by 11 percent a year since 2013. Sudanese householders with grid access consume significantly more electricity than their regional peers. Consequently, the sector has been increasing spending on thermal fuels and capital investment to meet the demand. The Government of Sudan (GoS) is subsidizing the sector by fully covering the cost of fuel and capital investment. The amount of this subsidy in 2017 was estimated to be SDG 14.7 billion (US$667 million), which amounted to 13.5 percent of GoS expenditure and 1.8 percent of gross domestic product (GDP) in that same year. This level of subsidy has significant implications for Sudan's fiscal and macroeconomic management.

The subsidy does not reach the poor due to their limited access to electricity. Most electricity access is provided for urban and relatively rich segments of the population. Electricity access in Kordofan and Darfur regions is particularly limited. The sector has been connecting a significant number of customers to the grid, but the increased access has been mostly offset by population growth.

In the coming years, sector costs will likely increase exponentially and may trigger a power crisis. Sector costs will continue to increase due to the use of imported fuels and capital investments needed to meet growing demand. These costs require payment in U.S. dollars, which will be very expensive given Sudan's rapidly depreciating local currency. The sector's operational cost, which is largely the cost of fuel, is projected to increase by 50 percent every year and reach SDG 560 billion (US$1.3 billion) by 2023. Given the ongoing economic crisis and the GoS's heavily constrained access to external financing, there is a risk that the GoS cannot sustain the current subsidy level for fuel and capital investment. This will create fuel shortages and constrain thermal generation output, resulting in the quality of electricity service deteriorating, with frequent and long load shedding.

Figure ES.1: Projected Sector Revenue Gap and Subsidy Needs to 2023



Source: World Bank staff calculation

A range of policy measures can mitigate increases in sector costs. Key actions the sector can take to mitigate cost increases are (a) using low-cost power from Ethiopia and Egypt by optimally utilizing the existing interconnection, (b) redirecting available investment capital away from thermal generation to domestic solar and wind generation, and (c) curbing demand growth through efficiency measures and price signals. All of these measures can be implemented in the relatively short term. In particular, power imports from Ethiopia and Egypt can potentially save US$200 million a year without major capital investment.

The GoS may set an interim tariff target to guide the short-term tariff transition. The current level of tariff, by far the lowest in Sub-Saharan Africa, is not sustainable and needs to be placed on an upward trajectory. However, in the context of Sudan, additional revenue through tariff increase will do little to close the revenue gap in the short term due to the exponential growth in costs driven by macroeconomic factors outside the sector's control. Therefore, operational cost recovery through tariff revenue is a moving target. In such a context, an interim tariff that is independent of macroeconomic factors can guide the sector's short-term tariff pathway for several years. After achieving the interim target, the sector can set a new target based on the sector and macroeconomic contexts at that point. The impact of tariff increase on the poor will likely be limited as most of the poor are not connected to the grid. However, it will likely affect the urban middle-class population. The GoS can implement a reform package that will gradually increase the tariff and strengthen the social security net for those affected. Such reform plans need to be strategically and effectively communicated to ensure understanding by the public, especially the middle class. In addition to increased revenue, tariff is an effective instrument to curb unsustainable demand growth and thus avoid increases in fuel and capital investment needs.

Finally, the sector needs to strengthen its planning capacity and corporate governance structure. The sector's planning has so far focused on system expansion to meet growing demand, paying limited attention to sector sustainability and cost optimization. The GoS needs to develop in-house capacity to carry out least-cost planning for electrification, power system development, and demand-side management. To remain relevant, the plan will need to be flexible, reflecting changing sector context and financing availability. In addition, the sector's current corporate governance does not allow sector companies to make autonomous investment and pricing decisions. To further improve sector efficiency and transparency, the GoS may consider commercialization and corporatization of sector companies while clearly delineating roles and responsibilities for policy making, regulation, and operational management among sector entities.

Given the current volatility in political and economic circumstances, short-term policy actions are critical to paving the path for sector recovery. Such options are listed in the table below.

Table ES.0.1: Potential Short-term Actions for Sector Recovery (1–2 Years)

Actions	Responsible Entities
Optimizing cross-border trade *(These low-cost measures can save up to US$200 million a year.)* • Complete technical studies and implement remedial measures to increase power trade in cooperation with EAPP and the governments of Ethiopia/Egypt. • Agree on new/revised PPA as needed. • Make supplementary investment to enable enhanced power trade.	SEHC and SETCO
Tariff adjustment/energy efficiency *(These measures will reduce electricity consumption growth and create an enabling environment for tariff reform.)* • Set interim target for tariff adjustment.	MoWRIE, including ERA

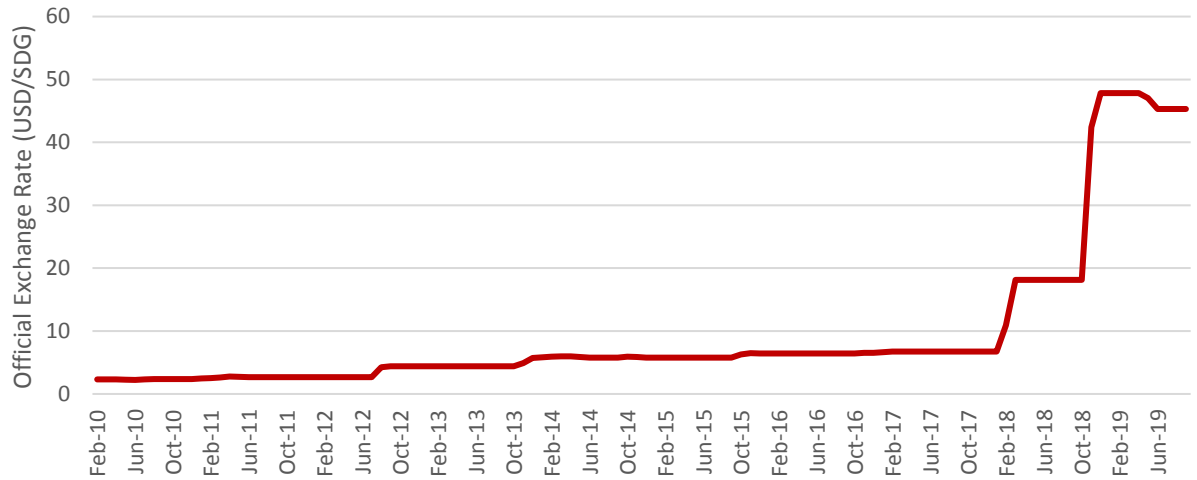
Actions	Responsible Entities
• Raise the GoS's internal awareness of electricity subsidy. • Prepare and launch communications campaign for tariff reform. • Reduce lifeline tariff threshold to 100 kWh/month and promote energy efficiency. • Introduce peak/off-peak pricing once technically feasible.	
Least-cost planning/private sector engagement *(These measures will allow optimal allocation of budgetary resources and strengthen GoS capacity to engage the private sector.)* • Carry out least-cost generation and electrification planning. • Redirect planned capital investment to renewables while piloting renewable energy IPPs. • Engage the private sector in the off-grid electrification space.	MoWRIE

This electricity sector diagnostic review constitutes the first step of the World Bank's engagement in Sudan's energy sector. Additional analysis and technical assistance to help sector recovery will be carried out to inform both policy decisions by the GoS and engagement by other development partners. In the next phase of engagement, the World Bank will review the energy sector in its totality, with specific focus on fuels.

Introduction

1. **Sudan's economy faces extremely complex challenges.** The secession of South Sudan in 2011 has resulted in the loss of oil revenue, which constituted more than half of the Government's budget at the time. Furthermore, Sudan was placed under economic sanctions by the United States in 1997. These sanctions were partially lifted in October 2017, allowing for financial and trade transactions between U.S. citizens/entities and their Sudanese counterparts. However, the legacy of the long economic isolation remains and is exacerbated by the inclusion of Sudan on the list of countries that sponsor terrorism. Several successive changes in the administered exchange rate contributed to uncertainty about the macroeconomic framework. Sudan's economic performance continued to deteriorate in 2018 with GDP declining by 2.3 percent, inflation at 64.8 percent, and the Sudanese Pound devaluing rapidly (Figure 0.1). While economic sanctions imposed by the U.S. were lifted in 2017, Sudan remains on the State Sponsors of Terrorism List.

Figure 0.1: Evolution of Exchange Rate Between Sudanese Pound and United States Dollar



Source: World Bank

2. Public and external debt remain high and unsustainable. Since the early 1990s, Sudan has faced major economic challenges stemming from severe indebtedness and the accumulation of significant external arrears. Sudan's external debt was at US$58 billion in 2018, the equivalent of 111 percent of GDP, with about 84 percent in the form of accumulated arrears. Sudan has been in nonaccrual status with the World Bank Group since 1994, and development aid to support economic productivity and human development outcomes has been scant. With a still-overvalued exchange rate, weak business environment, and loose fiscal policies financed by money creation, external imbalances and inflationary pressures are likely to intensify, raising risks of disorderly adjustment and compromising growth prospects over time.

3. **Sudan is a net importer of fuel products.** Although Sudan was historically an oil exporter until the secession of South Sudan, its current domestic production and distillation capacity is insufficient to meet the domestic demand. Therefore it is importing a significant amount of oil products from the international market.

4. **Electricity generation is the largest usage of oil products in Sudan.** Sudan consumed approximately 5.1 million tons of oil products in 2016[1], of which approximately 40 percent was for thermal electricity generation and 17 percent for transport. It is likely that the share of electricity in oil-product consumption has increased since 2015 due to increased power generation from thermal plants. The fuel for private or commercial use is regulated and significantly subsidized by GoS.

5. **In Sudan's challenging economic context, electricity is important in two ways.** First, it plays a vital role in economic growth and diversification, which have been key to the development agenda following the secession of South Sudan and the loss of oil revenue. Access to affordable and reliable electricity will underpin development. Second, efficient and effective management of the electricity sector is important to ensure fiscal sustainability of the GoS. In Sub-Saharan Africa, it is common for the electricity sector to incur major financial losses and require capital injection by government budgetary instruments. Such fiscal burdens reduce the availability of resources for other sectors, including health and education, which are key to a country's efforts to lift people out of poverty.

6. **Against this backdrop, the GoS requested that the World Bank reengage in the energy sector to strengthen its performance.** As the first step of the reengagement, the World Bank carried out this diagnostic review of the Sudanese electricity sector to identify key sector challenges and formulate approaches to addressing them, and to identify engagement opportunities. The review was carried out in close consultation with GoS counterparts and is based primarily on data provided by the GoS.

7. **The diagnostics review provides electricity sector facts and prospects, as well as options for sector recovery.** Part 1 presents the historical electricity sector profile of Sudan, including its governance structure, key performance indicators, and challenges. Part 2 presents the near-term sector outlook, including investment, access, and financial prospects. Part 3 presents options to strengthen sector performance, with particular focus on financial performance. The review includes broad spectrum analysis, including legal and institutional frameworks, sector financial flow, geospatial analysis of electricity access, least-cost analysis of generation expansion, and Poverty and Social Impact Assessment (PSIA). Considering the limited availability of data related to Sudan in the public domain, this diagnostic review is an important contribution to understanding the state of the sector and its ability to serve the needs of the Sudanese people.

[1] Data shared by GoS.

PART 1: SECTOR PROFILE

1.1: Sector Governance Structure

8. **Sudan's electricity sector has been governed by the Electricity Act since 2001.** This act designated the National Electricity Corporation (NEC) as the body for electricity generation, transmission, and distribution, and designated the Electricity Regulatory Authority (ERA) as the sector regulator. The legal framework has been generally open to private participation in the areas of generation, transmission, distribution, and third-party access to the transmission system. However, the act did not provide detailed provisions for how the private sector could engage in the electricity sector; for example, there are no clear procedures for independent power producers (IPPs) to obtain licenses and other permits specific to the sector, and the sector lacks detailed and transparent regulations and procedures.

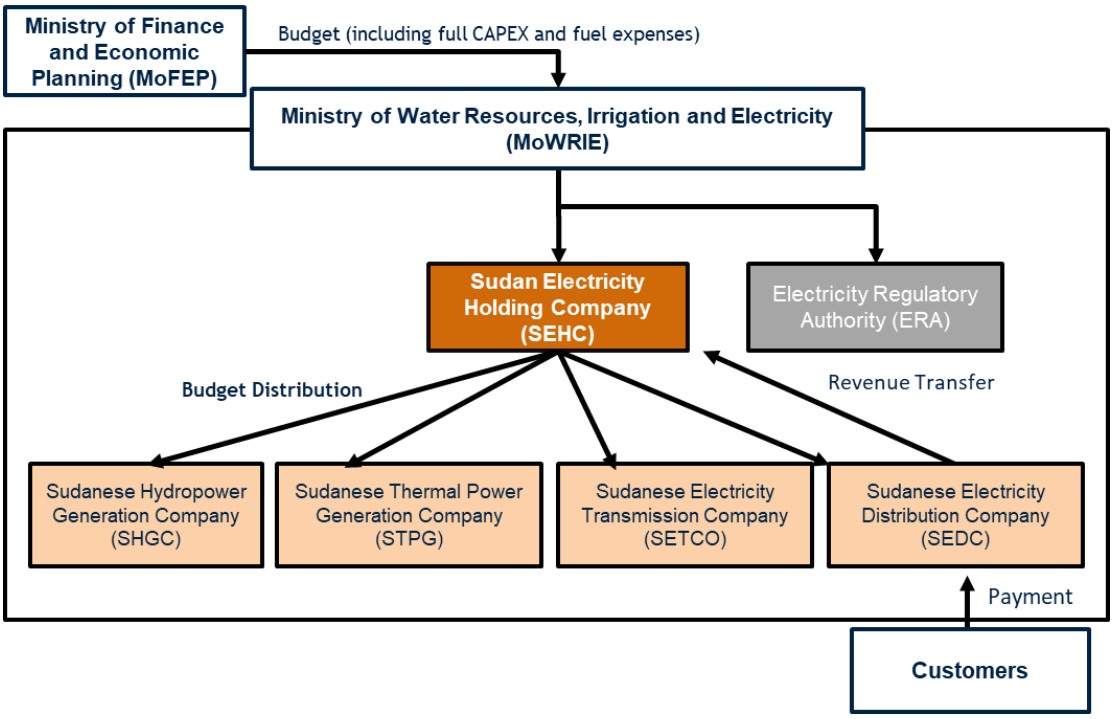
9. **The GoS is strengthening its legal framework to attract more private investment in the sector.** The Electricity Act is now being updated to reflect the current sector context; it is expected to include provisions for renewable energy and energy efficiency and clarify the role of the regulator in tariff-setting. It also aims to provide for greater openness to the private sector by allowing private investment in isolated grids and clarifying that the Sudanese Electricity Holding Company (SEHC) is the off-taker for power purchase agreements (PPAs). Beyond the power sector, the GoS in 2013 introduced the National Investment Act, which set certain incentives for priority sectors for Sudan's development. More recently, the GoS has been finalizing the Public-Private Partnership Act (PPP Act) to increase private participation in infrastructure development, including the electricity sector. The PPP Act is expected to establish a High Commission for public-private partnerships (PPPs) and a dedicated PPP Unit in the Ministry of Finance and Economic Planning (MoFEP). This revised legislation is expected to provide more incentives for private investment in the sector and promote renewable energy and energy efficiency.

10. **Since 2010, the sector has been unbundled along technical lines.** Until 2010, the NEC was functioning as a vertical integrated utility, a state-owned entity fully responsible for electricity generation, transmission, and distribution. In 2010, it was unbundled into five separate electricity companies (later reduced to four).[2] In 2016, the SEHC was created to oversee and own four of the subsidiary companies. Within the unbundled structure, each subsector is self-contained and has a clear technical function. The mandate of the Sudanese Hydropower Generation Company (SHGC) was extended in 2018 to include other forms of non-hydro renewable energy generation such as solar and wind.

11. **Despite unbundling, sector companies have limited autonomy.** All sector companies remain integral parts of the Ministry of Water Resources, Irrigation, and Electricity (MoWRIE) and are largely dependent on government budgetary allocations. Key functions such as finances, investment, and personnel management are determined by the Ministry, not by the individual sector companies. The SEHC receives an annual appropriation from the MoFEP for the entire electricity sector and allocates it to the four SEHC subsidiaries based on the quantity of electricity supplied to the Sudanese Electricity Transmission Company (SETCO) (for the SHGC and Sudanese Thermal Power Generation [STPG]) and the power supplied by SETCO to the Sudanese Electricity Distribution Company (SEDC). This financial flow is illustrated in Figure 1.1.

[2] The unbundling led to the creation of Merowe Hydropower Company and the SHGC. The Merowe Hydropower Company was merged into the SHGC in 2017.

Figure 1.1: Institutional Structure and Financial Flow of Sudan's Electricity Sector



Note: CAPEX = Capital expenditure.

12. **In addition, sector companies do not have access to finance for their own investment decisions.** The sector fully relies on the MoFEP to secure financing to invest in the power system. Capital investments in the sector are financed directly by the MoFEP, which also services the debt, although the assets are shown in the balance sheets of the respective sector companies. Given the GoS's fiscal constraints, the MoFEP engages external donors (largely Arab and Chinese) to fund investments. Such high dependence on external financing creates unpredictability with regard to available financing and poses major challenges to investment planning and execution.

13. **The roles and responsibilities of sector entities are ambiguously defined.** The function of each sector entity is often defined only in its broad principles, leaving key decisions to ad hoc committees. In particular, the responsibilities of planning and investment are disbursed between MoWRIE and the SEHC, with significant overlaps. This approach enables flexibility in the decision-making process but also results in important weaknesses: a dilution of responsibility and accountability, unpredictability of decisions, and a decreased level of commitment in technical departments. For instance, the responsibility for electricity access is spread between MoWRIE, SEDC, and state governments. The main sector functionalities are expanded upon in Annex 5.

1.2: Sector Policies and Plans

14. **The electricity sector is prominently featured in Sudan's national development strategy.** The Sudan National Quarter-Century Strategy (2007–2031) presents the national development goals across sectors. Goal 3 — sustainable development — features a number of goals related to the electricity sector, including loss reduction, interconnection with East Nile Basin countries, energy efficiency, data management, and capacity building. It should be noted, however, that the strategy was developed before the secession of South Sudan in 2011, when the entire country context significantly changed. Nonetheless, the strategy is being referred to as a national strategy to which the sector contributes.

15. **The electricity sector operation is currently guided by the '2015–2020 Power Sector Development Framework.'** The framework presents the list of priority investments for the electricity sector. The list of projects includes the development of thermal generation to meet growing demand, acceleration of the rehabilitation and strengthening of the distribution system, and addressing the fuel storage issue for thermal plants. The sector framework is built on long- and medium-term power system plans for 2012–2031 prepared by an international consulting firm in 2012. The plan was built on system modelling for generation and electrical network expansion based on a least-cost approach. The plan suggests that the least-cost option for Sudan will derive from coal-based thermal generation in the Red Sea as the base load and supplemented by gas-powered generation to meet peak demand. The plan also suggests various network reinforcements, including interconnection with Ethiopia and maintenance of existing hydroelectric plants. Importantly, renewables such as solar and wind were not identified as part of the least-cost options.

16. **The focus of the framework is to identify key projects that require financing.** The document correctly identifies future sector challenges, particularly the projected widening financial gap between sector resources and financing needs for operation, maintenance, and new investments. Although the framework document presents a technically sound and detailed description of power sector challenges and investment needs, it does not spell out the sector priorities and overarching strategy, as its focus is mainly on physical investment proposals to the MoFEP.

17. **Only a portion of the projects identified in the sector framework have actually been implemented.** Notably, there has been a significant difference between the framework document and the investments that actually took place. Table 1.1 compares key generation investments referenced in the sector framework and the system plan. It is evident that around half of the proposed generation projects did not take place. Major delays of between one and three years were also observed, even for the projects that were commissioned. This is partly due to the unpredictability of financing availability, which is at the discretion of the MoFEP and must be raised from external partners. In addition, the system plan overestimated demand growth. In 2017, a peak load of 4,534 MW was forecast, while the actual peak load for the year was 2,972 MW; less investment in generation was thus required. Consequently, the framework document and the underlying system plan have limited relevance to future planning.

Table 1.1: Large Power Generation Projects Included in Power System Plans and Their Actual Status of Implementation

Name of Project	Technology	Installed Capacity (MW)	Planned Commission Year	Current Status
Upper Atbara	Hydro	320	2015	Commissioned in 2018
Roseires Dam Heightening	Hydro	280	2012	Completed in 2013
Sennar Upgrading	Hydro	26	2015	Not started
Red Sea 1	Thermal (coal fired)	300	2016	Not started
Red Sea 2	Thermal (coal fired)	300	2016	Not started
Al Fula 1	Thermal (crude oil fired)	135	2015	Not started
Al Fula 2	Thermal (crude oil fired)	135	2015	Not started
Al Fula 3	Thermal (crude oil fired)	135	2015	Not started
Kosti 1	Thermal (crude oil fired)	125	2012	Commissioned in 2015
Kosti 2	Thermal (crude oil fired)	125	2012	Commissioned in 2015

Name of Project	Technology	Installed Capacity (MW)	Planned Commission Year	Current Status
Kosti 3	Thermal (crude oil fired)	125	2013	Commissioned in 2015
Kosti 4	Thermal (crude oil fired)	125	2013	Commissioned in 2015
Roseries Upgrading	Hydro	442	tbc	Not started
Sennar new power plant	Hydro	146	tbc	Not started

Source: STPG and SHGC.

18. **The GoS has an ambitious plan to expediate electricity access.** In line with the Sustainable Energy for All (SE4ALL) initiative, the GoS has set the target of universal access to electricity by 2031, of which at least 80 percent is expected to be through grid connections. According to the SEDC's plan, the GoS will connect about 250,000 households per year — a large increase from 2016 to 2018, when the sector added 100,000 households per year. Such scale-up will need significant investment; as the distribution network extends beyond higher-density cities and settlements, the cost and time needed to connect new customers is likely to increase. The GoS also plans to provide 2.5 million stand-alone solar home systems (SHSs) by 2023 for areas where grid connection is not feasible.

19. **The GoS is committed to attracting private sector investment to the electricity sector.** Given the constrained public financing and known renewable energy potential, the GoS has made considerable efforts to attract private investment to the sector. Since 2001, the GoS has attempted to develop private sector projects, including the 257 MW thermal project in Khartoum, which was awarded to DIT Power Kilo-X, a Malaysian company. More recently, the GoS engaged developers for utility-scale solar in West Omdurman, Port Sudan, and Berber, as well as for a wind project in Dongola. These developers were engaged based on unsolicited proposals without a competitive process.

20. **Despite the GoS efforts, no private sector project has been finalized to date.** Many projects progressed as far as the signing of a Memorandum of Agreement between the company and the GoS but did not advance further. The developers often lacked the project development experience, as well as the technical and financial capacity, needed to advance the project. The GoS often requested a low tariff, which was insufficient for developers to secure adequate return to attract debt financers. The only exceptions are semi-IPPs contracted to provide temporary rental thermal capacity under PPAs: SEMI FZE of Turkey (16 MW at Nyala in 2017 and 30 MW at Great Darfur in 2018) and Karpowership of Turkey (150 MW at Port Sudan). All power plant rental contracts include a minimum load factor guaranteed by the GoS, and the GoS supplies generating fuel for the power plants. These rental agreements are short term, with a duration of six months to three years.

1.3: Sector Performance

21. **Sudan's electricity demand has been growing faster than the demand in many other countries in Sub-Saharan Africa.** Between 2013 and 2017, demand in Sudan increased by 70 percent — at an average rate of 11.3 percent each year (Table 1.2). A demand growth of 10 percent annually is considered high in Sub-Saharan Africa. Sudan's steep rise in demand is largely the result of increasing per customer electricity consumption and industrial demand rather than the addition of new customers. As of 2017, there were 2.2 million residential customers, constituting about 60 percent of the total electricity sales. Residential users in 2017 consumed an average of 275 kWh per month, high by Sub-Saharan African standards, which show consumption typically ranging between 50 and 100 kWh per month. The breakdown of usage by customer category can be seen in Annex 3.

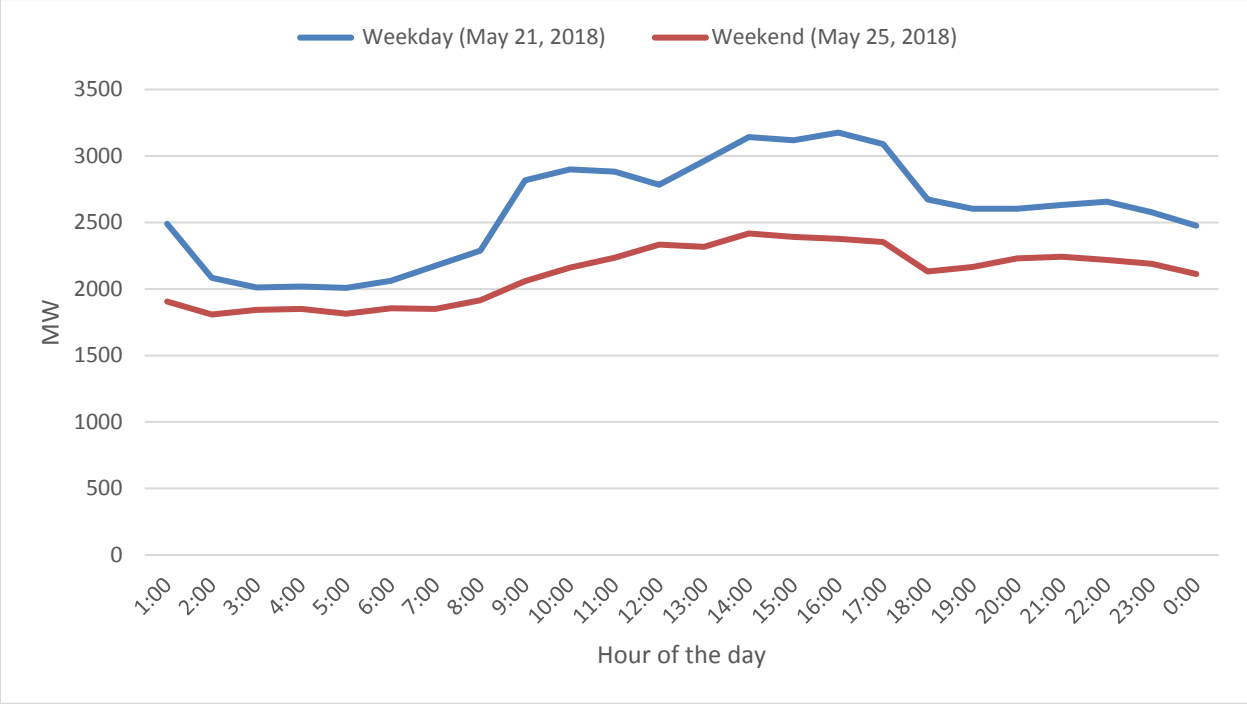
Table 1.2: Electricity Demand Growth in Sudan (%)

2013	2014	2015	2016	2017	Average
13.1	12.8	9.0	11.5	10.1	11.3

Source: SEDC.

22. **The electricity demand doubles in the summer season, resulting in significant power outages.** During peak hours in June and July, Sudan's hottest months, as much as 40 percent of electricity demand is subject to load shedding. This is because the use of air-conditioning represents the largest share of household and commercial electricity consumption in Sudan. Load shedding is likely to be the biggest concern for electricity users and is also driving them to overuse electricity when it is available (for example, overcooling spaces and food). In 2018, 3,146 MW was recorded as the peak demand, which has been increasing at the pace of 200–300 MW per year since 2015. Since recorded peak demand excludes unmet demand during load shedding, the real demand was likely higher.

Figure 1.2: Daily Load Curve in May 2018



Source: World Bank staff calculation

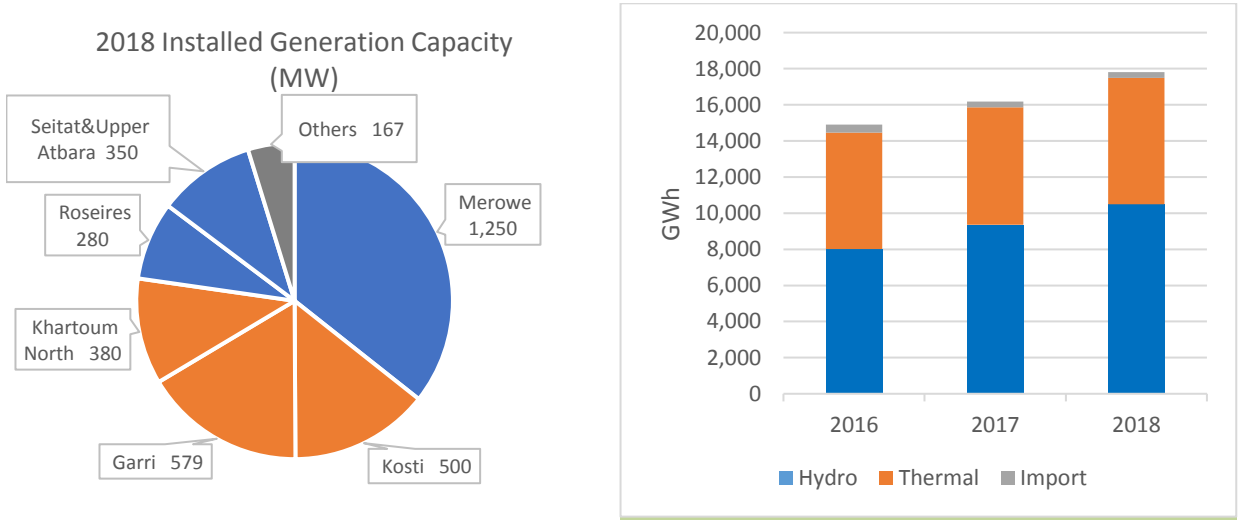
23. The demand growth has been driven by increases in both grid connectivity and levels of consumption. The number of grid-connected customers and electricity consumption per customer both increased at an average rate of 5 percent a year between 2016 and 2018. Rising per customer usage of electricity is likely due to increased ownership and usage of electric appliances as well as increasing urbanization (i.e., rural populations moving to cities and living with households that are connected to electricity). Table 1.3 provides an overview of selected electric appliance ownership in Sudan. This is not an exhaustive list, and households are likely to have additional appliances such as light fixtures, electric cookers, and cellphones.

Table 1.3: Ownership of Key Electric Appliances in 2014 (grid-connected households)

	Percentage of households that own the asset	Average number of units
TV	78.7	1.1
Radio	27.0	1.0
Computer	8.4	1.2
Refrigerator	59.8	1.1
Fan	73.9	2.7
Air conditioning	22.6	1.5

24. **In an attempt to keep up with rising demand, the GoS invested in large-scale thermal and hydro generation.** With an installed capacity of 3,500 MW in 2018, and expected capacity of 4,500 MW in 2019, Sudanese power generation capacity is one of the largest in Sub-Saharan Africa. Of the installed capacity, 48 percent is hydroelectric, and 52 percent is thermal (consisting of diesel, heavy fuel oil [HFO], crude oil, and other forms of petroleum fuels). As of 2018, the Merowe Hydropower Plant is by far the largest generation asset in Sudan, with 1,250 MW of installed capacity. The composition of generation capacity is illustrated in Figure 1.3, and a full list of current and prospective generation assets is provided in Annex 1. Sudan is part of the Eastern Africa Power Pool (EAPP) and imported 319.6 GWh of power from Ethiopia in 2017.

Figure 1.3: Sudan's Electricity Generation



Source: Sudanese Electricity Holding Company
Note: Total Installed Capacity - 3,676 MW. Available Capacity - 3,400 MW.

25. **Sudan is home to vast but largely untapped renewable energy resources.** It is evident that Sudan's solar and wind energy potential is greater than that of most other Sub-Saharan African countries.[3] Solar potential is high almost everywhere in Sudan. Wind energy potential, which is more location-specific than solar, is high along the coast of the Red Sea and in the inland area of the Northern State. The GoS is also exploring geothermal potential at the Bayuda site in the Northern State. However, these renewable

[3] Solar and resource map in Sub-Saharan Africa can be viewed at Global Solar Atlas (https://globalsolaratlas.info/) and Global Wind Atlas (https://globalwindatlas.info/).

resources are largely untapped. Hydropower is the only renewable resource that has been significantly used for power generation: Sudan currently has 2,000 MW installed capacity of hydropower.

26. **Recent investments in the sector prioritized thermal generation.** The share of electricity generated from thermal power plants has risen to about 46 percent and is expected to continue rising, as most of the generation plants in the pipeline are thermal (see Annex 1). The GoS is expected to commission additional 1 GW thermal generation units in Garri and Port Sudan plants in 2019. Sudan's oil production and refinery capacity (for example, Khartoum refinery) is small, and domestic production is only capable of providing for household/commercial fuel use (for example, vehicle fuels and liquified petroleum gas). Hence, most of the fuels used for electricity generation are imported. Crude oil is imported from South Sudan and is directly tapped at Kosti power station. Sponge coke (SC) is a low-value byproduct from Khartoum refinery operation. Other fuels, including HFO, heavy coked gas oil (HCGO), and diesel are largely imported from the international market.

Table 1.4: 2017 Thermal Fuels for Power Generation in Sudan

Fuel	Quantity (tons)	Percentage
HFO	198,420	11.7
HCGO	158,663	9.3
Diesel	25,845	1.5
Light diesel oil (LDO)	448,861	26.4
SC	136,181	8.0
Crude oil	731,962	43.1
Total	**1,699,932**	**100.0**

Source: Sudanese Thermal Power Generation

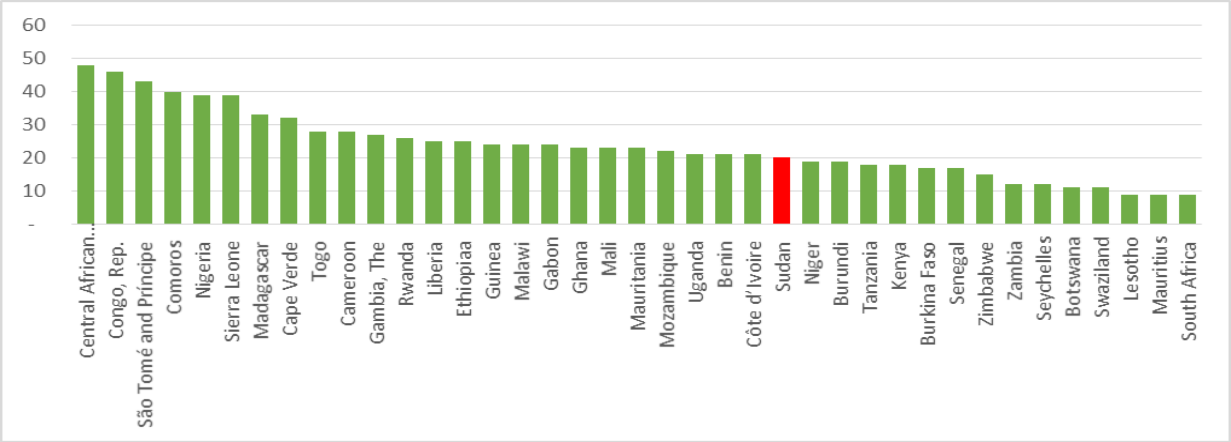
27. **GoS investment in maintaining generation assets has been adequate despite challenges.** Most of Sudan's generation assets are of significant age but are in good working order. Roseires HPC (280 MW) is 45 years old; original parts of Khartoum North thermal plants (380 MW) are 33 years old; and Garri 1–2 thermal plants (456 MW) are 16 years old. The high availability rate of these generation assets indicates that they have been maintained in sound working condition despite the challenge of procuring spare parts while the country was under economic sanctions. The GoS has worked with countries with which it has economic relationships — Arab countries, as well as China and Turkey — to procure the necessary spare parts. An important exception is Garri 4 thermal plant (110 MW), which is not operating at full capacity due to technical deficiency.

28. **Sudan's power system is relatively well maintained and performs at average or high levels compared to other systems in the region.** Transmission and distribution losses in Sudan are low at 20 percent (15 percent distribution losses and 5 percent transmission losses). This level of loss is comparable to Kenya and Tanzania and lower than Ghana and Uganda (Figure 1.4). Bill collection rate is 93 percent, due to the quality of commercial management and the universal installation of prepayment meters. System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), which measure the duration and frequency of unplanned power interruptions, are 9.18 hours and 10.14 times per year, respectively. This puts the country in the first quartile in Africa for both indexes but places it below the international average of 5.5 hours and 6.4 times per year, respectively. Sudan's performance compares well with other African countries, but there is room for improvement. It should be noted that Sudan does suffer from regular load shedding in summer peak hours due to generation shortage.

Table 1.5: Sudan's Power System Scorecard (2017)

Indicators	Sudan		Regional Benchmarking
Transmission loss	5.4%		Relatively low compared to Sub-Saharan African average, with room for improvement.
Distribution loss	15.1%		Average for Sub-Saharan Africa, with room for improvement.
Collection rate	93%		High by Sub-Saharan African standards (99.7% of residential users are prepaid - 2017).
SAIDI	9.18 hours (2017)		System duration of interruption per customer. Average by Sub-Saharan African standards, with room for improvement.
SAIFI	10.14 (2017)		Average frequency of interruption per customer. Average by Sub-Saharan African standards, with room for improvement.
Cost of service	US¢20/kWh (2017)		Average by Sub-Saharan African standards.
Average electricity tariff	US¢1.5/kWh (2017)		Lowest in Sub-Saharan African. Dropped to US¢0.7/kWh in 2018 due to currency depreciation.

Figure 1.4: Power Transmission and Distribution Losses (%) in African Countries



Source: Regional Data based on Kojima and Trimble (2016)

29. **The relatively sound performance of the system is underpinned by a local manufacturing base that supplies the power sector.** Over the years, local industries have developed in response to sanctions imposed on the country. These industries manufacture and supply prepayment meters, small- to medium-size transformers, and other equipment. Local industries also have a recognized level of competence in civil works and construction of transmission lines and distribution systems. This local manufacturing base and skilled labor have helped the sector to maintain its infrastructure despite having limited access to the international market.

30. **The level of staffing is also relatively efficient by regional standards.** Sudan's power sector staff productivity, measured as the number of customers per employee, was 275:1 in 2017. This ratio is comparable to that of power sectors in countries considered strong performers in Africa, whether under private management (Côte d'Ivoire and Kenya [partly]) or public management (Rwanda), and confirms that the technical operation of Sudan's system is efficient by regional standards.

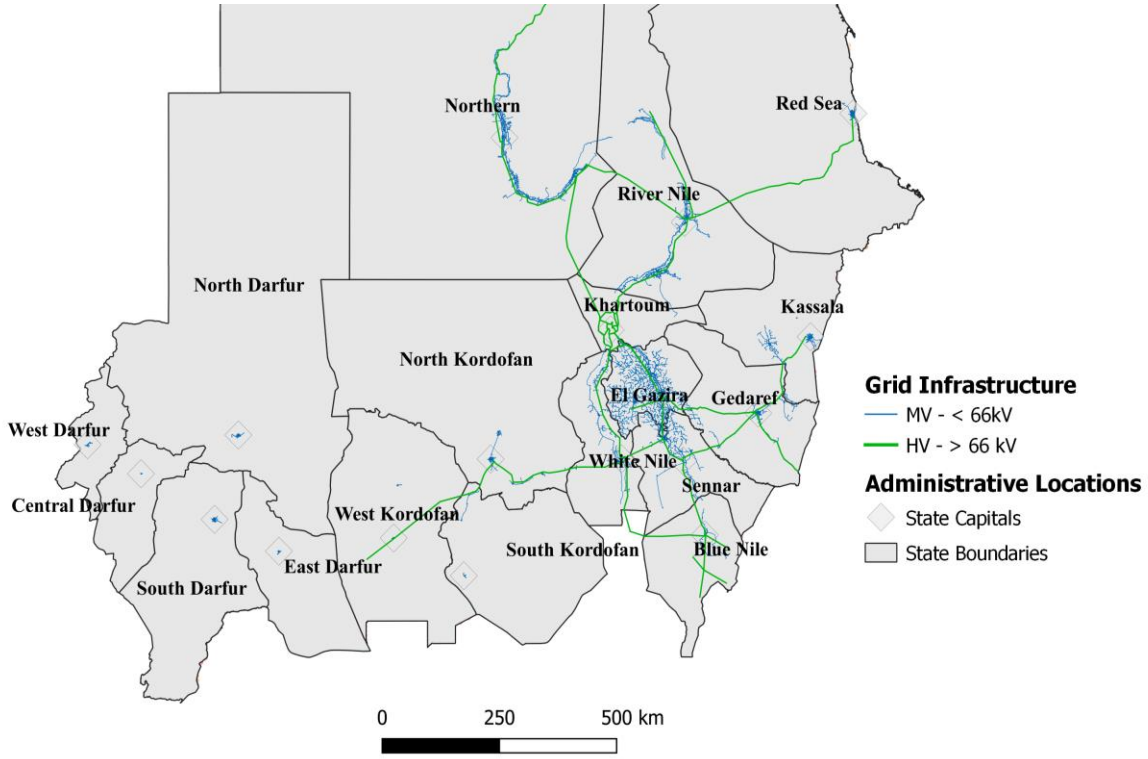
31. **Sudan's power system covers its major demand centers but does not reach the western part of the country.** Although the Sudanese power system is among the most technically and commercially efficient in Sub-Saharan Africa, the transmission and distribution systems are in need of extension and rehabilitation. The states around Khartoum are equipped with several transmission lines, but other states have very limited or no coverage. The five states comprising Darfur, in the southwest of Sudan, have no transmission line coverage, as the 220 kV line ends at Babanosa before reaching East Darfur. In the eastern parts of the country, transmission lines are devised to connect state capitals and power generation plants. In the north, transmission lines are built along the Nile River to cover riverside towns. There are also 500 kV lines that connect Merowe HPC, Khartoum, and Atbara. Sudan's power system map is provided in Annex 4.

32. **Expansion of the transmission network to the west is under way but only slowly.** Investment is being made to extend the grid to the western parts of the country, with financing from several donors. However, the inability of the MoFEP to fulfill its debt repayment obligations to the Arab Funds (e.g., Islamic Development Bank, Arab Fund for Economic and Social Development, Qatar Fund for Development) interrupted the implementation progress. In the states with no transmission coverage, diesel-fueled isolated systems are serving the state capitals. Hence, all 18 state capitals are served either by the national grid or by isolated grids. The GoS plans to interconnect these systems as transmission coverage is increased.

33. **Sudan's power system connects to the regional market, but the volume of power trade is limited.** Sudan is an active member of EAPP and has 200 MW interconnections with Ethiopia at 220 kV and Eritrea at 66 kV levels, both of which are operational. The PPA between Sudan and Ethiopia includes 100 MW of firm capacity at US¢5 per kWh and provisions for monthly scheduled and annually scheduled electricity trade from Ethiopia to Sudan with the volume and price to be mutually agreed for each transaction. However, this interconnection and PPA have been used only at an average capacity of 40 MW, which is less than a quarter of the capacity provided for in the PPA. This is due to the lack of coordinated system operation between the two countries, which is needed to ensure stability in the system when increasing import volume. Sudan also completed a 300 MW interconnection with Egypt in February 2019, but the two countries are still negotiating the PPA; therefore, the price has not been agreed.

34. **The distribution network is concentrated in several states of the country.** As illustrated in the geographic information system (GIS) network map in Figure 1.5, Sudan's distribution network is concentrated in (a) Khartoum State, (b) Jazeera State, and (c) along the Nile rivers (Blue Nile from Ethiopia, White Nile from Uganda, and the Nile to Egypt). To a degree, this concentration represents the size of the population in each state: Khartoum and Jazeera States are the two most populous in Sudan, with a combined estimate of 11 million people and a number of settlements and agricultural fields along the Nile rivers.

Figure 1.5: High-voltage and Medium-voltage Network in Sudan



Source: World Bank Staff Analysis
Note: HV = High voltage; MV = Medium voltage. The boundaries, colors, denominations, and any other information shown on this map do not imply, on the part of the World Bank Group, a judgement on the legal status of any territory, or any endorsement or acceptance of such boundaries.

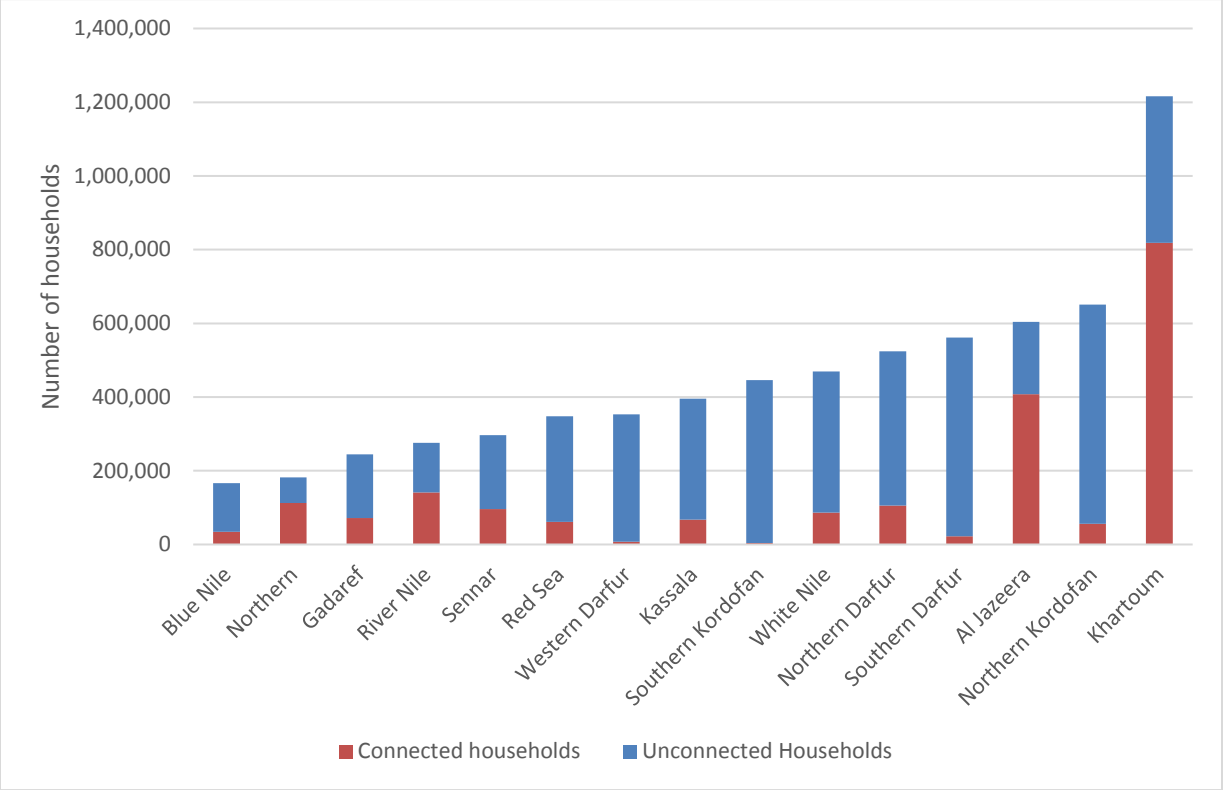
35. **Each state is responsible for investing in the distribution network.** Sudan follows a decentralized model of electrification, in which each state is financially responsible for the construction of the MV network. In addition, the cost of providing low-voltage lines and last-mile connections is borne by electricity users, with varying levels of connection fees depending on the location and the length of lines to be built. Over the past several years, the average connection fee has been around SDG 4,500 with cost fluctuations resulting from fluctuating exchange rates. In Sudan's decentralized model of electrification, the national government, including the SEDC, functions as the technical adviser on project design and the operator of built assets.

36. **The estimated rate of electricity access in Sudan in 2018 was 32 percent, with significant regional disparity.** Approximately 2.2 million households are connected either by national grid or isolated systems, while about 4.5 million households remain without access to electricity.[4] In line with the geographical locations of distribution grids, the highest electrification rates (60 percent and above) are in Khartoum, Jazeera, River Nile, and Northern States. The largest electricity access deficit is observed in the

[4] The national household baseline poverty survey in 2015 indicated that 46.6 percent of Sudanese households use grid-connected electricity as the primary source of energy. However, due to methodological reasons, the survey may be overestimating the electrification rate (for example, one connection may be serving multiple households). A comprehensive survey based on multitier framework (MTF) of electricity access is needed to accurately estimate the actual level of access.

Darfur and Kordofan regions, where the national grid has not reached despite the significant population residing there.

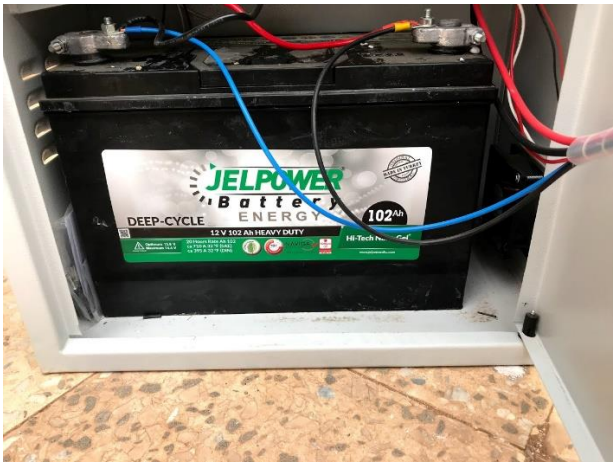
Figure 1.6: Estimated Number of Unelectrified Households in Each State



Source: SEDC, World Bank analysis

37. **To expediate electrification, the GoS is investing in off-grid electrification solutions.** The GoS, through the SEDC, designed SHSs, and by mid-2018 had distributed 15,000 of them. The SHSs are distributed using SEDC branches in state capitals where national grids have not reached. To enhance affordability of the SHS, an installment payment option is offered in cooperation with a local government-owned bank. There is also a United Nations Development Programme-Global Environment Facility (UNDP-GEF) funded program to scale up solar water-pumping systems through a cost-sharing scheme. High-quality (that is, certified by Lighting Global) SHSs from international suppliers are absent from the Sudanese market, partly due to the challenges local businesses face in accessing foreign currencies.

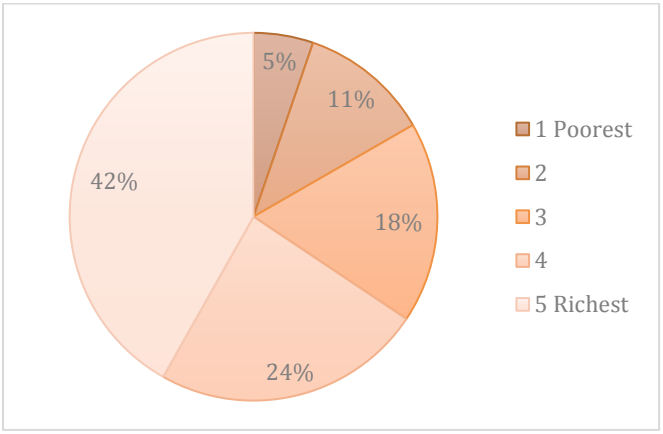
Figure 1.7: SHS Model Developed by the GoS



Source: World Bank, courtesy of Sudanese Electricity Distribution Company

38. **Most of the electrified households belong to the relatively richer segments of the Sudanese population.** In Sudan, 67 percent of electrified households fall within the fifth and fourth quintiles (42 percent and 24 percent, respectively), whereas only 5 percent of connected households are in the poorest (first and second) quintiles. This disparity partly reflects the fact that most of the distribution network has reached only urban populations in relatively well-off states such as Khartoum and Jazeera. Access remains particularly low for rural households.

Figure 1.8: Distribution of Households Connected to the Grid (2014)



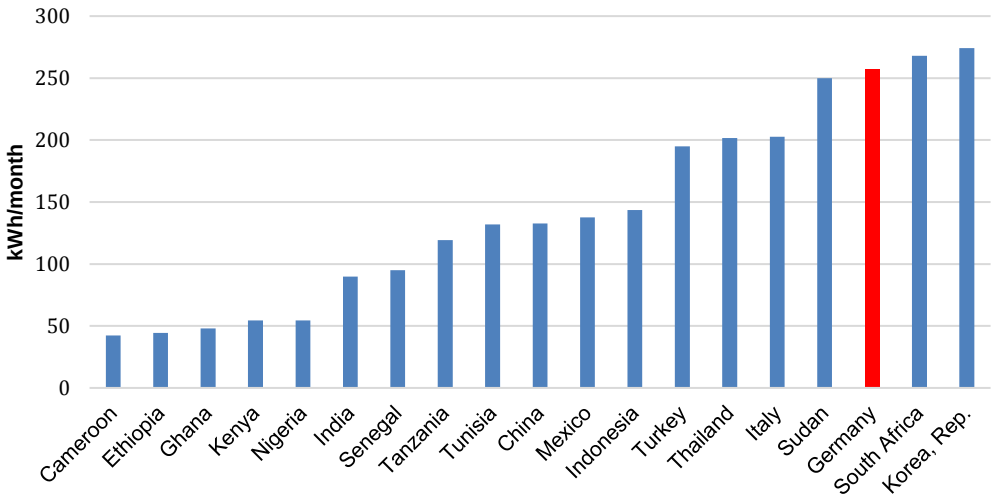
Source: NHHBPS 2014. 1 represents the poorest quintile and 5 represents the richest quintile.

39. **The high consumption levels of Sudan's grid-connected households are equivalent to levels in some Organization for Economic Co-operation and Development (OECD) countries.**[5] In 2014, the average household consumption of electricity in Sudan was 308 kWh per month, with consumption ranging from 177 kWh among the poorest quintile to 368 kWh among the top quintile. Urban users consume significantly more than rural users; those in the richest quintile consume on average 439 kWh, around 180 kWh more than the rural population in the richest quintile. The level of energy efficiency of electrical appliances in Sudan, including air conditioners, is considered low, due to the history of restricted access to the international market under economic sanctions. As Figure 1.9 illustrates, the average

[5] Using 2014 tariff structure.

Sudanese household consumes as much electricity as a German household and five times that of a Kenyan household. Cooling is likely to be the largest use of electricity in Sudan. It is estimated that approximately 40 percent of electricity consumption goes to space cooling or air conditioning in Sudan due to summer temperatures that often exceed 40°C.

Figure 1.9: International Comparison of Sudan's Residential Electricity Consumption

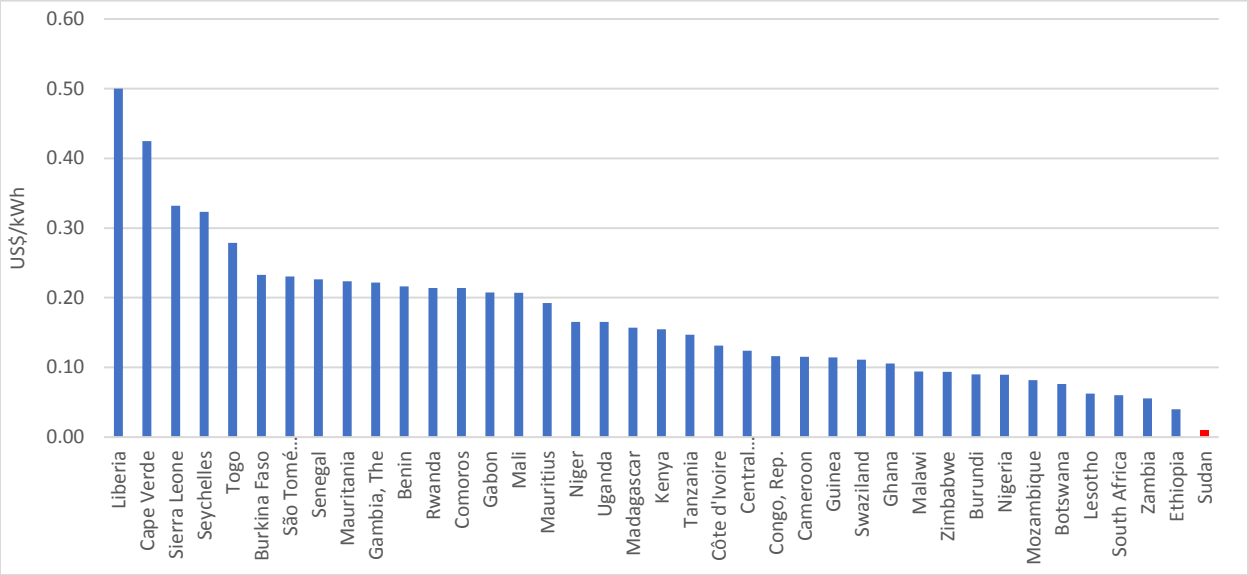


Source: World Energy Council, World Bank

40. **The high level of consumption is partly driven by the very low tariff level.** Sudan's average electricity tariff is the lowest in Sub-Saharan Africa and among the lowest in all of Africa (Figure 1.10). The tariff was already one of the lowest in Sub-Saharan Africa in 2015, but subsequent depreciation of the Sudanese pound reduced tariff significantly in real terms. The average retail tariff in Sudan in 2017 was SDG 0.35 per kWh or US¢1.5 per kWh.[6] The tariff charged to businesses and large consumers whose use exceeds 400 kWh per month was increased by 88 percent in 2018, but the average tariff is still far below the cost of supply and remains low by international standards. The average tariff nominally increased by 80 percent between 2015 and 2018, but after adjusting for domestic inflation, the real average tariff decreased by 30 percent over the same period.

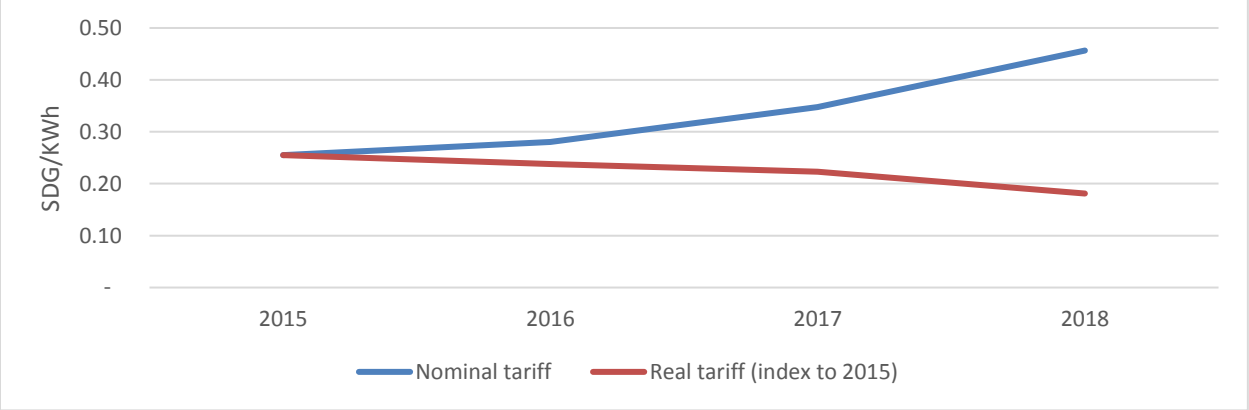
[6] Ranging from US¢0.8 per kWh for the social tariff to US¢9 per kWh for large industries.

Figure 1.10: Comparison of Electricity Tariffs in Sub-Saharan Africa



Source: Trimble et al. 2016

Figure 1.11: Nominal and Real Electricity Tariff in Sudan



Source: World Bank Calculation

41. **The lifeline tariff in Sudan is very generous.** The tariff structure includes a low lifeline tariff of US¢0.7 per kWh with a high threshold of 200 kWh per month (in most countries with a lifeline tariff, the threshold is 100 kWh per month). This relatively generous threshold of social tariff reflects higher per customer consumption than is seen in other countries in Sub-Saharan Africa, as well as the GoS's aim of ensuring that electricity is affordable. As seen in Table 1.6, almost half of the residential users fall within the lifeline tariff category. The data also suggest that the highest-consuming 1 percent of users account for more than a quarter of electricity consumption. A full tariff table is presented in Annex 2.

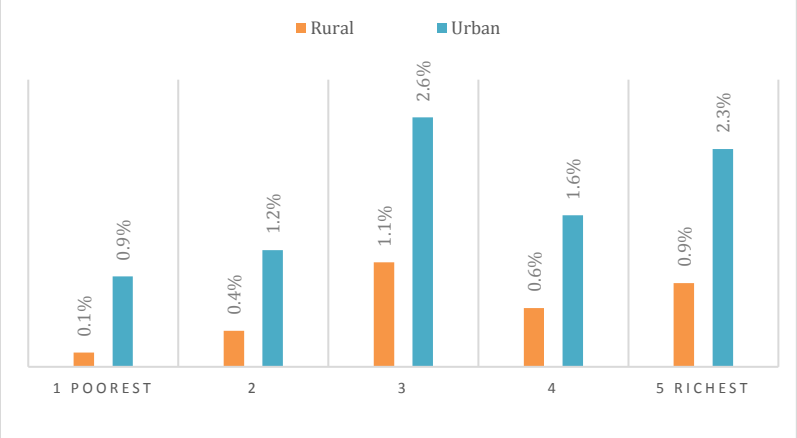
Table 1.6: Percentage of Households and kWh Consumed by Tranche

	% of Households	% of kWh Consumed
Residential (0–200 kWh)	46	21
Residential (201–400 kWh)	46	39
Residential (401–600 kWh)	5	8
Residential (601–800 kWh)	1	3
Residential (801–1,500 kWh)	1	3
Residential (1,501+ kWh)	1	26

Source: National Household Budget and Poverty Survey (NHHBPS) 2014

42. **At the current low tariff, electricity is considered affordable, even for the poorest population in Sudan.** Based on the National Household Baseline Survey in 2015, average electricity consumers spend 1 percent of their monthly budget on electricity. In some of the most urbanized and electrified states, the share increases to 3 percent (Figure 1.12). According to the framework developed by the SE4ALL initiative, which defines subsistence level as 30 kWh per month, electricity is considered affordable if a household does not have to spend more than 5 percent of its total monthly income to purchase it (World Bank and International Energy Agency 2015). Accordingly, electricity is affordable to all connected households in Sudan, as they pay a low tariff of SDG 0.15 for the first 200 kWh.

Figure 1.12: Expenditure for Electricity Consumption as Share of Household Expenditure



Source: National Household Budget and Poverty Survey (NHHBPS) 2014. The percentage covers only households connected to the grid.

1.4: Sector Challenges

43. **The electricity access rate is growing very slowly, and increasing grid connections incurs financial loss to the sector.** In the past five years, the GoS has been connecting approximately 100,000 new households annually to the grid, providing electricity services to an estimated 560,000 people every year. However, the additional connections are largely offset by rapid population growth. Population in Sudan has been growing by about 2.4 percent a year, which translates into an annual increase of close to 1 million people. Consequently, the access rate lags behind population growth, and the number of households without electricity access is likely to be increasing. From a financial perspective, connecting more customers to the grid is loss-making. Although the sector and SEDC do not pay to connect households (which are covered by state governments and customers' own contributions), tariff

underpricing below the level of cash required to cover operational expenditure (OPEX) means that every kWh sold represents a net financial loss.

44. **The sector policy and planning framework is weak.** The current sector framework document and system plan are obsolete, meaning that sector investment is not guided by least-cost options such as renewables. Hence, the GoS's current and future investment plan is predominantly thermal. There is also underutilization of existing assets, most notably the interconnection with Ethiopia. The weak policy and planning framework is hindering the country's progress toward key energy goals. In the international analysis of Regulatory Indicators for Sustainable Energy (RISE) conducted in 2017 by the World Bank and the Energy Sector Management Assistance Program (ESMAP), Sudan scored 32 out of 100, slightly below the Sub-Saharan African average of 35. Sudan fared relatively well with regard to electricity access, owing to its target for universal access by 2031 and its program to scale stand-alone systems and affordable electricity. In contrast, Sudan's scores on energy efficiency and renewable energy were low, largely due to the lack of incentives and financial mechanisms to support these policies.

Table 1.7: RISE Score of Sudan

	Overall	Electricity Access	Energy Efficiency	Renewable Energy
Sudan	32	53	24	19
Sub-Saharan African Average	35	—	—	—

Source: ESMAP (2017) RISE
Note: Full score is 100.

45. **The sector has not yet created a sufficiently enabling environment for private sector investment.** The low cost-recovery rate and reliance on government subsidies reduce the private sector's appetite for investment. Private sector investors require a financially strong off-taker with adequate revenues from electricity sales to support monthly payments under PPAs. Many countries that have a sound power sector but lack a credit record receive the support of international financial institutions (IFIs) to provide guarantees on behalf of utilities and/or governments. Such credit enhancement tools build private sector confidence. In the case of Sudan, however, the GoS is in arrears with IFIs. Until these arrears are addressed, guarantees and credit enhancement instruments will be difficult to secure. Furthermore, there is a weakness in the GoS's capacity to effectively procure IPPs. In the past, the GoS opted to accept unsolicited proposals without launching competitive tenders based on a least-cost plan (LCP). The private sector also has to go through complex procedures for PPPs, involving a sometimes unpredictable decision-making process undertaken by various committees and councils. The long processing time and the uncertainties concerning the outcome represent risks for potential investors.

46. **Macroeconomic factors also create barriers for private investment.** These factors, such as domestic inflation and the fluctuating exchange rate, present significant risks to private investors. Private investors in the power sector usually require most transactions and PPA tariffs to be denominated in hard currencies such as U.S. dollars or euros. Given that the sector's revenue from electricity sales is in Sudanese pounds, the sector's ability to make timely payments to IPPs will be compromised by domestic inflation and the corresponding depreciation of the currency. The private sector will consider this a significant payment risk that could result in default. Such risk can typically be mitigated by government guarantees, usually issued by the Ministry of Finance, to backstop the payment to IPPs. However, the value of these guarantees is based on a government's track record of honoring such guarantees. In the case of the Sudanese government, whose borrowings are mostly in arrears, the track record is poor. To attract more private sector investment and lending, the credit standing of the GoS would need to be restored and the issue of international payment arrears settled.

47. **Restricted access to foreign currency is limiting private sector growth.** IPPs need access to foreign currency for financing and operations in Sudan, as well as parts and maintenance services, and these must be procured quickly to avoid lengthy shutdowns of plants. Off-grid companies, which invest in and/or operate mini-grids as well as stand-alone SHSs, also need access to foreign currency to import the products and materials necessary for their operations. Such access to foreign currency is a challenge in Sudan, partly due to international banks' overcompliance with international sanctions. Although U.S. sanctions were lifted in 2017, investors and lenders remain cautious about engaging with Sudan due to the reputational risk associated with transacting business with a country still on the U.S. list of states sponsoring terrorism. There is also a perceived risk of sanctions being reimposed during the PPA period, which typically lasts 20 years.

PART 2: FINANCIAL OUTLOOK

48. **In the coming years, the sector will face increasing challenges.** Using sector financial models and a least-cost planning tool, a projection has been made to illustrate how the sector will look in the medium term, by 2023. Key factors that affect the sector's future performance include domestic inflation, growing demand, generation mix, and the level of tariff. The combination of these factors is driving the sector toward a worsening financial performance.

2.1: Sector Cost and Revenue

49. **The sector's full cost of service was estimated at SDG 43.5 billion (US$2.4 billion) in 2017 or US¢18 per kWh.** This level of cost of service is approximately average in Sub-Saharan Africa. The full cost of service includes the following:

(a) The cash OPEX of the sector was SDG 19.1 billion (US$1.3 billion) in 2017. This figure represents the minimum expenditure that the sector needs to cover (for example, fuel, basic operation and maintenance [O&M], and staffing). The cash OPEX recorded in financial statements by sector companies totaled SDG 8.5 billion. However, the financial statements use the official exchange rate, which is subsidized by the Central Bank of Sudan (CBoS) and undervalues the cost of fuel import. Using the parallel market exchange rate for fuel cost, estimated cash OPEX in 2017 was SDG 19.1 billion.

(b) CAPEX annuity was SDG 24.5 billion (US$1.1 billion) in 2017. This is a theoretical figure that the sector would need to recover if it were to raise debt to finance its existing assets through repayment of principles and interest. In reality, however, the MoFEP raises finance (debt and grant) or secures budgetary resources and on-grants them to the sector companies. Given that some CAPEX is funded by grants and budgetary allocation that do not require repayment, the real CAPEX annuity is likely to be lower. It is assumed that the CAPEX annuity is incurred in U.S. dollars and the parallel exchange rate is being used to estimate the figure in Sudanese pounds.

50. **The sector generated cash revenue of SDG 4.3 billion (US$194 million) in 2017, far below the minimum OPEX.** Owing to the almost universal use of prepayment meters by residential customers, collection loss has been low at 5-6 percent. Revenue has been increasing at 20-30 percent a year, owing to increased sales and consumption of electricity. However, the amount of revenue falls far below sector costs by all measures. The cost recovery ratio, with multiple levels of cost, is presented in Table 2.1. In most of the countries in Sub-Saharan Africa, the electricity sector does not recover full cost due to the large scale of new investments needed and the limited ability of users to pay higher tariffs. Nonetheless, the full cost is a useful indication of the level of revenue that the sector needs to generate in the long run to be sustainable.

Table 2.1: Sector Cost and Revenue (2017)

Unit: SDG, billions	Cost	Revenue	Cost Recovery Rate (%)
Cash OPEX (official rate)	8.5	4.3	50
Cash OPEX (parallel rate)	18.9		23
Theoretical full cost (cash OPEX and CAPEX annuity, parallel rate)[7]	43.5		10

[7] Full cost includes (a) cash OPEX: costs required to pay for operating cash expenses, basically including OPEX minus depreciation (which is the main noncash item), and (b) CAPEX annuity: the annuity of the utilities' asset base value at New Replacement Value, representing the recovery of the principal of the investment plus interest. A discount

51. **The revenue gap is significant and is widening quickly.** The gap between sector revenue and the cost of cash OPEX under the parallel rate[8] increased at an average rate of 40 percent a year between 2015 and 2017. The gap is driven by the increasing cost of fuel, which accounts for 85 percent of the sector OPEX. Since the GoS imports fuels used for thermal generation, it is exposed to domestic currency fluctuation. In 2017, the sector's revenue gap was SDG 14.7 billion (US$667 million).

52. **Sudan's electricity sector operation cost has been increasing exponentially due to a combination of factors, notably currency depreciation.** The largest factor in increasing cost is the depreciation of the Sudanese pound, which lost about 50 percent of its value per year over the past few years. Sudan's domestic refinery industry has been unable to meet the demand by the electricity sector, so the sector depends heavily on imported thermal fuels. Consequently, Sudanese pound currency depreciation immediately translates into increased sector operational cost. Such increase in operational cost is noticeable when accounted in parallel exchange rate but is less noticeable when the accounting practice uses the official exchange rate, which is tightly controlled by the GoS. Hence, policy makers in the GoS may have been unaware of the magnitude of the real cost increase the sector is going through.

53. **The rising cost is exacerbated by the increased use of thermal fuels and plants to meet the growing demand.** As noted earlier, Sudan's electricity demand has been increasing at a rate higher than 11 percent a year. Such rapid demand growth is driven by a combination of increasing numbers of customers and the widespread use of high-load appliances such as air conditioners and generators. The low level of tariff also encourages inefficient use of electricity, resulting in a consumption level equivalent to some OECD countries. Consequently, the electricity demand outstrips available generation in peak summer hours, when the load doubles. The sector has had to implement a significant load-shedding program, which affects livelihoods and economic activity in Sudan. It is likely that such load shedding has negatively affected people's confidence in the sector and their willingness to accept a higher tariff. Furthermore, adding new generation to meet the peak demand is a costly investment. For example, the GoS is currently constructing 1 GW of thermal plants, which will require an approximate investment of US$1 billion. Given the current fuel shortages in Sudan, there is a risk that fuel supply to the thermal plants will be interrupted even if they start their operation.

54. **Sudan's electricity tariff adjustment has been insufficient to keep up with rising costs and inflation.** The GoS modified the tariff structure in 2016 by charging higher rates to customers consuming more than 200 kWh per year. In 2018, the GoS increased by 88 percent the tariff for customers consuming more than 400 kWh per month. However, these efforts were insufficient to keep up with domestic inflation, which was around 20 percent per year between 2015 and 2017. Therefore, in real terms, Sudan's electricity tariff has decreased over the years. This real decrease in tariff is evident when the average tariff is expressed in U.S. dollars using the parallel rate. In 2015, the tariff was US¢2.1 per kWh, but in 2017, it was US¢1.6 per kWh.

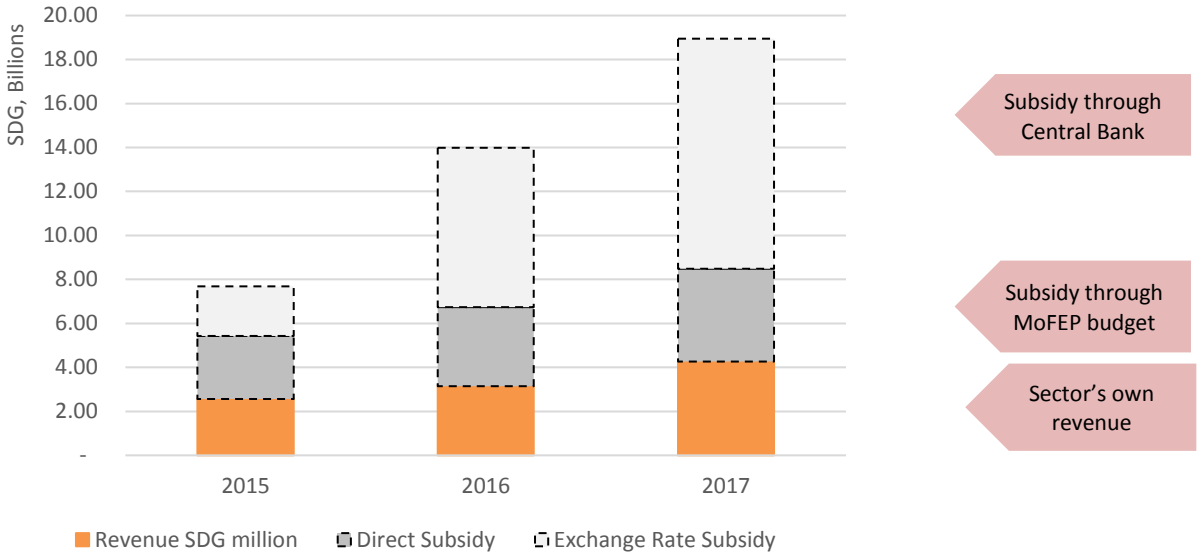
55. **To fill in the revenue gap, the sector is heavily subsidized.** The sector revenue gap for cash OPEX (parallel rate) was SDG 14.7 billion (US$667 million). The shortfall was made up by a direct subsidy of the

rate of 12 percent was applied to the market value of assets. This is a simplified theoretical calculation to represent what the tariff would be if all investments were to be made by the utility.

[8] OPEX under parallel rate is considered an appropriate benchmark because (a) in most Sub-Saharan African countries, it is unrealistic to recover CAPEX cost through sector revenues due to large investment needs and people's limited ability to pay, and (b) the GoS has recently modified official exchange to a rate much closer to a parallel rate.

MoFEP budget allocation of SDG 4.2 billion (US$191 million) and the CBoS, which covered SDG 10.5 billion (US$475 million) through the provision of the implicit exchange rate subsidy. The exchange rate subsidy was significant in 2017 because the official rate was about a third of the parallel price. In the same year, the combined subsidy amounted to 13.5 percent of GoS expenditure and 1.8 percent of GDP. The scale of subsidy is so significant that it is impeding sound macroeconomic management. It should be noted that this is cash OPEX only and does not include capital investments. Inclusion of CAPEX would at least double the revenue gap and the subsidy.

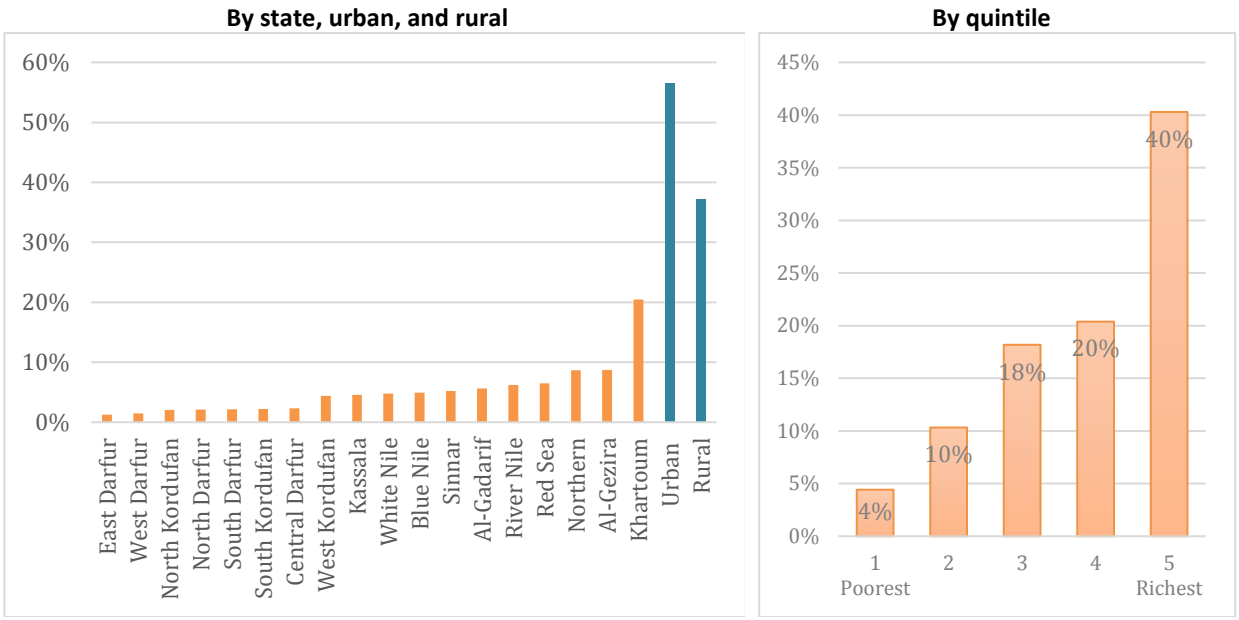
Figure 2.1: Historical Revenue Gap and Subsidy



Source: World Bank staff calculation

56. **The subsidy only minimally benefits the poor, who largely lack access to electricity.** Given that only 32 percent of the Sudanese population is connected to the electricity grid and most of those households are in the rich income quintiles, the distribution of electricity subsidy is highly regressive. A simple extrapolation shows that more than 60 percent of the subsidy benefits the richest 40 percent — that is, the two richest quintiles. By contrast, 5 percent of the subsidy goes to the poorest quintile. Across states, most of the subsidy goes to urbanized areas, such as in the State of Khartoum. The contrast is also visible between rural and urban areas, with the subsidy benefiting urban more than rural populations.

Figure 2.2: Distribution of Electricity Subsidy by Region and Quintile



Source: NHHBPS 2014

2.2: Medium-term Financial Outlook

57. **The electricity demand is projected to grow rapidly, at a rate of 10 percent annually.** Driven by greater user consumption and an increased number of connections (residential and non-residential), electricity demand is likely to grow by around 10 percent per year. Although this pace is fast by Sub-Saharan African standards, it is a conservative estimate in the Sudanese context. Between 2015-2017, the annual demand grew at a compound annual growth rate (CAGR) of 10.79 percent. The GoS projects 17 percent annual demand growth in the future, but given the supply constraints, the historical track record of 10 percent is more likely. At this pace, demand would double within seven to eight years. By 2023, demand is projected to grow to 28,000 GWh a year, with a peak demand of 5,200 MW.

58. **To meet the demand, the government is planning significant investment in thermal generation.** According to a five-year generation plan (2018–2023), the GoS intends to invest in a range of thermal generation of 3,500 MW by 2023. This mix is to include HFO, flare gas, and coal, as well as the addition of combined cycle units to existing plants to use flue gas. The GoS also plans to invest in solar and wind energy, as well as in additional interconnection with Egypt and Ethiopia, but the scale and capacity of these options are significantly lower than those of thermal (500 MW for solar and wind, 300 MW interconnection with Egypt, and 600 MW interconnection with Ethiopia). The list of pipeline generation plants is provided in Annex 1.

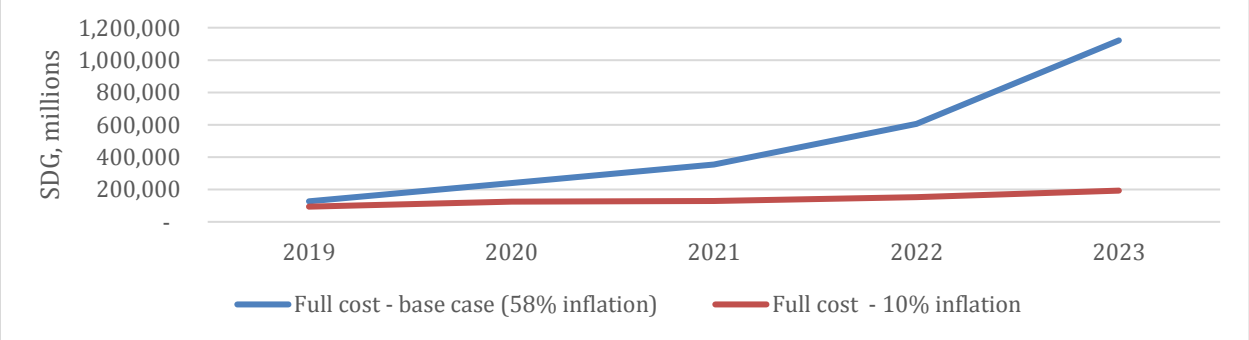
59. **With this plan, the sector cost will increase to approximately US$2.7 billion a year.** This figure includes an annual average capital investment (primarily thermal generation plants) and fuel procurement. Since new generation plants are normally constructed by international firms and thermal fuels are imported from the international market, the cost will be primarily incurred in U.S. dollars. By 2023, in U.S. dollar terms, the sector's full cost will increase by approximately 50 percent.

Table 2.2: Five-year Projection of Sector Cost

		2019	2020	2021	2022	2023	2018–2023
Cash operating costs	US$, millions	1,012	1,356	1,031	1,085	1,357	34%
Full cost	US$, millions	1,827	2,241	2,127	2,325	2,727	49%
Cash operating costs	SDG, millions	70,202	145,308	171,686	283,136	558,095	695%
Full cost	SDG, millions	126,797	240,097	354,202	606,380	1,121,372	784%

60. **With the current macroeconomic outlook, the sector cost in Sudanese pounds will grow exponentially, driven by domestic inflation and Sudanese pound depreciation.** For 2018–2023, the International Monetary Fund (IMF) projects an average annual inflation rate of 58.3 percent. This will directly translate into the depreciation of the Sudanese pound, which would be valued at US$1 = SDG 411 by 2023. This depreciation will have a major impact on sector costs, which are incurred primarily in U.S. dollars. In Sudanese pound terms, the full cost of the sector will rise to SDG 1.1 trillion by 2023, an increase of 780 percent from 2019. A scenario analysis that compares continued macroeconomic crisis (IMF projection of 58 percent annual inflation) and macroeconomic stabilization (annual inflation of 10 percent, which is close to the Sub-Saharan African average) shows that the macroeconomic factors will increase the sector cost by five times. Domestic inflation and Sudanese pound depreciation are external factors that are outside the direct control of the sector. With the current level of tariff, the sector's cost recovery will drop to a negligible 1.7 percent of cash OPEX and 0.85 percent of full cost by 2023. This would mean that virtually all sector costs would need to be covered by subsidies.

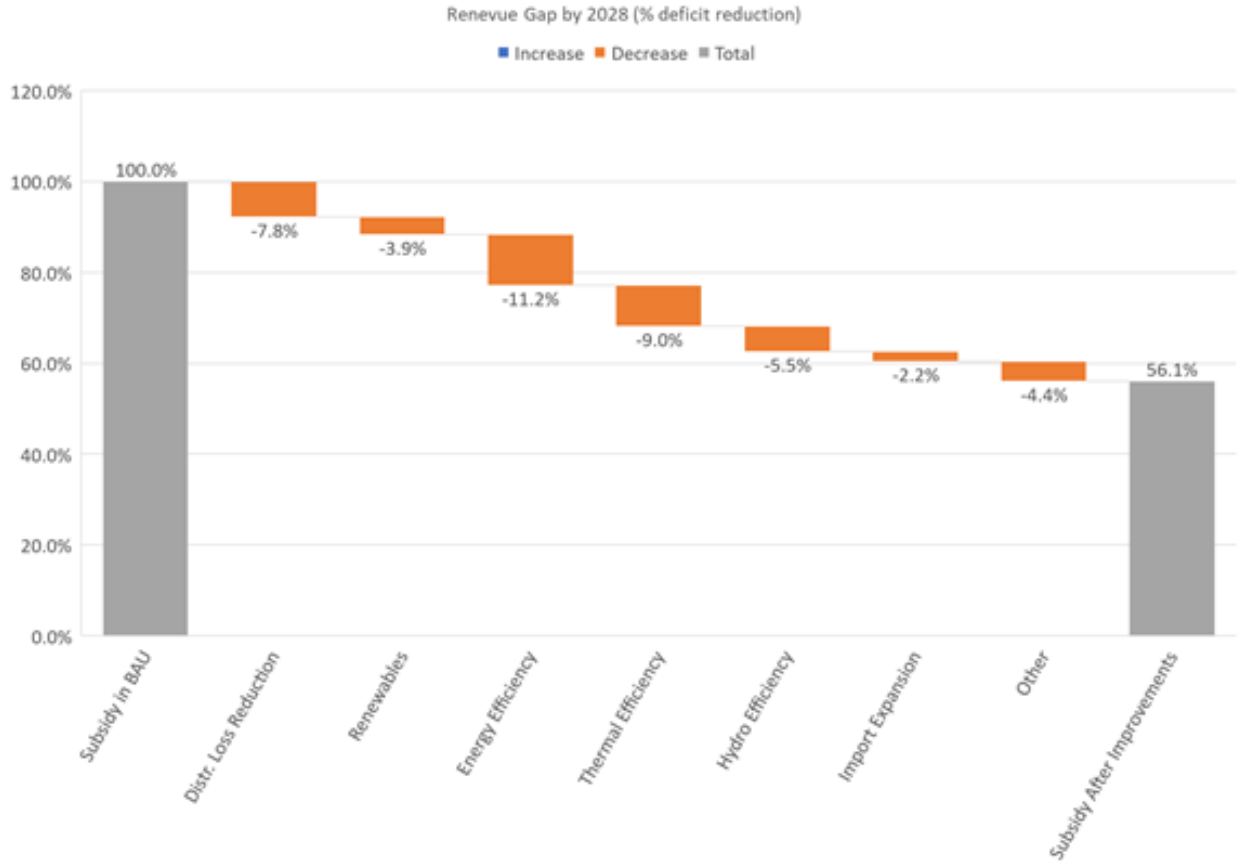
Figure 2.3: Impact of Inflation on Future Sector Cost



Source: World Bank Staff Calculation

61. **A range of cost-reduction measures exists.** These include improving supply-side efficiency, scaling solar/wind renewables, and importing from Ethiopia and Egypt. These measures could reduce the sector operational cash deficit by 45 percent by 2028 as compared to the base case scenario. Details of these measures are elaborated in Part 3.

Figure 2.4: Cost-reduction Measures to Reduce Sector Deficit



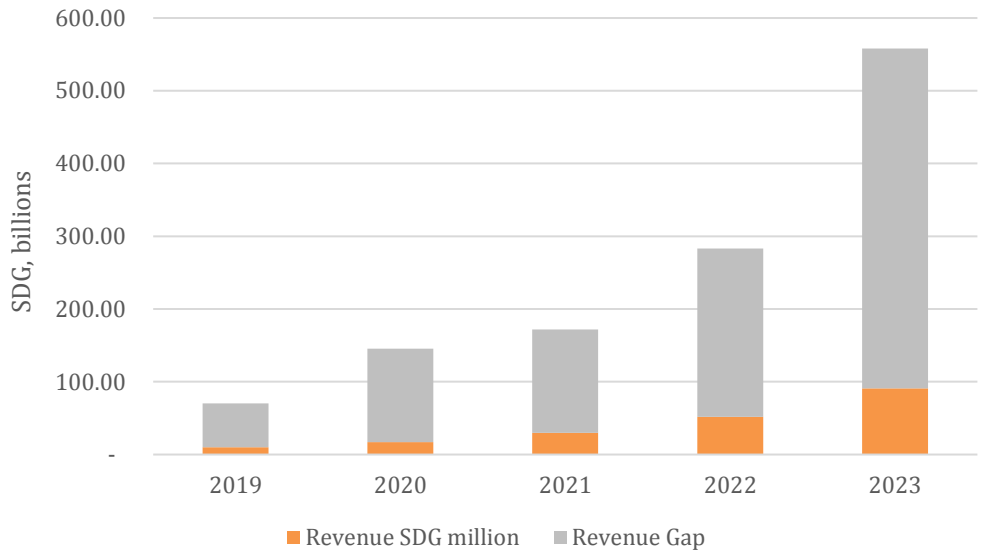
Source: World Bank calculation
Note: BAU = Business as Usual

62. **The remaining revenue gap needs to be covered by increased tariff revenue.** Approximately 15 percent annual increase of tariff in real terms would be needed by 2028 to cover the remaining gap. However, this is an increase needed in addition to inflation; the increase needed in nominal terms would be 70-75 percent per year. This pace of tariff increase is unlikely to be feasible, meaning that macroeconomic stabilization is a prerequisite if the sector is to recover full operational cost through tariff.

PART 3: OPTIONS FOR SECTOR RECOVERY

63. **Reaching operational cost recovery and containing the otherwise fiscally unsustainable cost of subsidies are the most important priorities for Sudan's electricity sector and are critical for economic stabilization.** The electricity sector subsidy accounted for 15 percent of GoS expenditure and over 2 percent of GDP in 2017. Under a business-as-usual scenario, the sector operating losses (deficits) will continue growing and the annual subsidy requirement is estimated to reach US$1.3 billion by 2023.

Figure 3.1: Projected Sector Revenue Gap to 2023



Source: World Bank Staff Calculation

64. **A range of measures would be necessary to increase sector revenues while carefully managing and reducing sector costs to reach operational cost recovery.** On the cost side, the key measures include conducting electrification and system expansion on the basis of a least-cost development plan, increasing the share of solar photo voltaic (PV) and wind power plants, improving energy efficiency, and increasing cross-border electricity exchanges with Ethiopia and Egypt. On the revenue side, measures would include adjustment of end-user tariffs and revision of tariff structure. In addition, the reform effort should be accompanied by rigorous and well-designed public communication, institutional improvements to delineate roles and responsibilities among sector oversight institutions, and the commercialization of sector companies. The sections below discuss these measures in detail while Table 3.1 presents a potential action plan of reforms.

Table 3.1: Potential Short-term Actions for Sector Recovery (1–2 Years)

Actions	Responsible Entities
Optimizing cross-border trade *(These low-cost measures can save up to US$200 million a year.)* • Complete technical studies and implement remedial measures to increase power trade in cooperation with EAPP and the governments of Ethiopia/Egypt. • Agree on new/revised PPA as needed. • Make supplementary investment to enable enhanced power trade.	SEHC and SETCO
Tariff adjustment/energy efficiency	MoWRIE, including ERA

Actions	Responsible Entities
(These measures will reduce electricity consumption growth and create an enabling environment for tariff reform.) • Set interim target for tariff adjustment. • Raise the GoS's internal awareness of electricity subsidy. • Prepare and launch communications campaign for tariff reform. • Reduce lifeline tariff threshold to 100 kWh/month and promote energy efficiency. • Introduce peak/off-peak pricing once technically feasible.	
Least-cost planning/private sector engagement *(These measures will allow optimal allocation of budgetary resources and strengthen GoS capacity to engage the private sector.)* • Carry out least-cost generation and electrification planning. • Redirect planned capital investment to renewables while piloting renewable energy IPPs. • Engage the private sector in the off-grid electrification space.	MoWRIE

3.1: Measures to Manage Costs

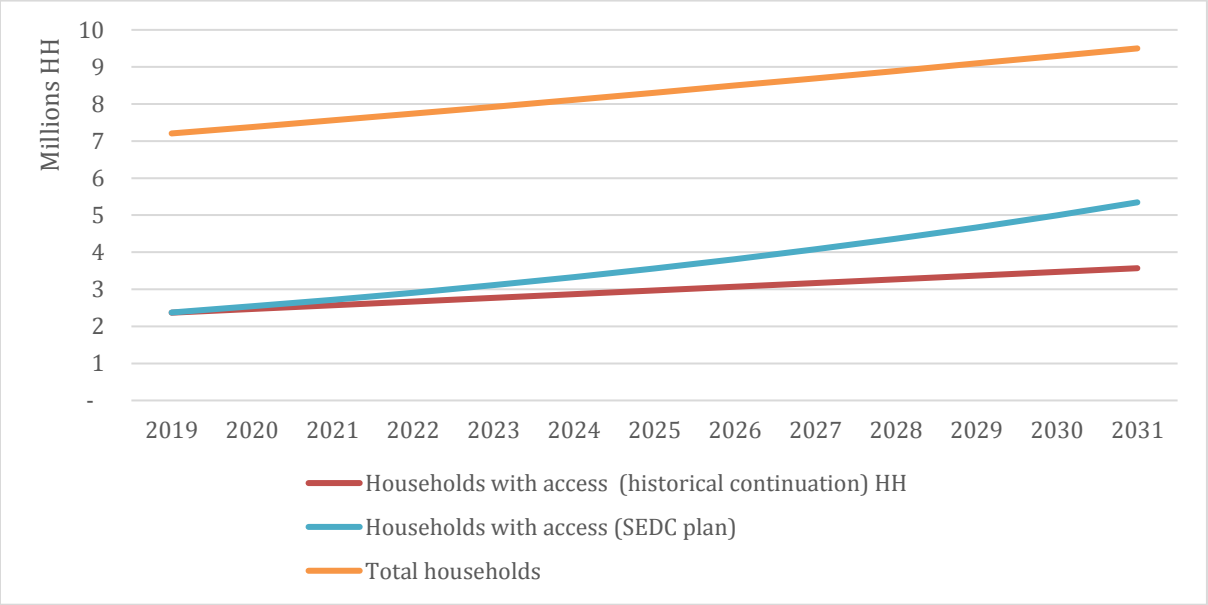
Strengthening Least-cost Planning

65. **Sudan's population is expected to grow significantly, which poses challenges for electrification.** The population is growing at a pace of 2.4 percent a year. By 2031, it is expected to increase to 56 million from its current level of 40 million. This change represents an additional 1 million people each year. Achieving universal access will require that electricity access grows at a rate faster than population growth.

66. **With the current plan, the GoS is unlikely to achieve its universal access target.** The GoS plans to increase grid-connected households to 5.3 million by 2023. Although this will more than double the number of households connected to the grid as of 2018, it will only achieve an electrification rate of 56 percent (Figure 3.2). To achieve universal access, the GoS needs to connect 600,000 new households per year — six times the current rate of connection, which is a very ambitious target.[9]

[9] This is based on the population forecast by the United Nations Department of Economic and Social Affairs (UNDESA) that Sudan will have approximately 56 million people in 2031, with the assumption that the household size of 5.4 per household remains the same.

Figure 3.2: Historical and Projected Electricity Access in Sudan

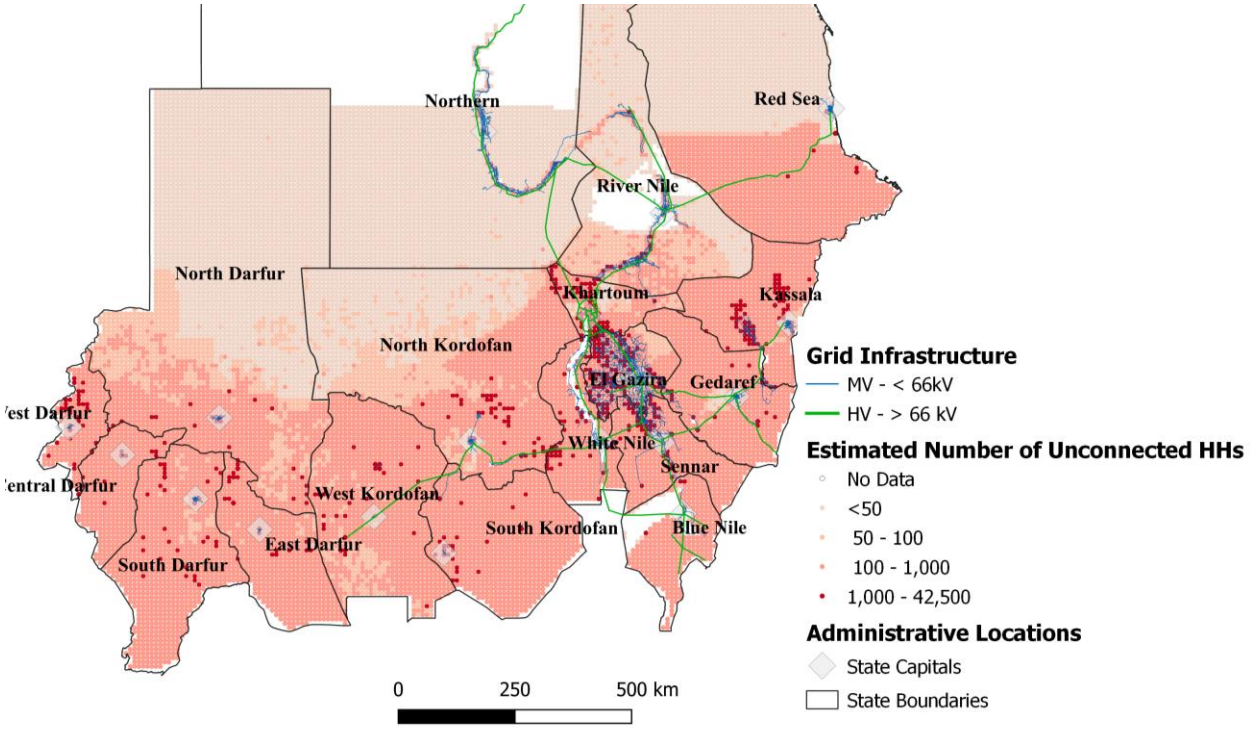


Source: Figure based on United Nations projection of population in Sudan, 2015 household survey, and SEDC customer data.
Note: The projection can vary depending on geographical distribution of population growth and household size.

67. **A multipronged approach with both grid and off-grid electrification would be required to accelerate electrification efforts.** If the current pace of new grid connections and population growth continues, roughly 60 percent of the Sudanese population (6 million households) would need to be served by off-grid electricity. The GoS plans to distribute 2.5 million SHSs by 2031, but this will not meet the demand of 6 million households. To scale up the SHS market in Sudan, the GoS needs to effectively work with the private sector. The GoS currently contracts out the assembling of its own SHS model by using private contractors, but importing internationally distributed, Lighting Global certified products may be a more cost-effective solution to take advantage of economies of scale. The GoS can incentivize the local private sector to distribute SHSs. Mini-grids may also provide cost-effective solutions for relatively densely populated settlements in Sudan. However, the experience of other countries in Sub-Saharan Africa indicates that the development of mini-grids requires substantial public funding to reduce the investment cost and make them commercially viable. Therefore, careful economic screening needs to take place before committing resources to mini-grid development. The preliminary geospatial analysis in Figure 3.3 suggests that significant grid densification opportunities exist in Khartoum and Jazeera States, and high-density settlements potentially suitable for mini-grids (marked with red dots) exist in the Kordofan and Darfur regions.

68. **The GoS can use planning tools to carry out electrification in a least-cost manner.** Specifically, the GoS could use its existing high-level GIS capability and its extensive data on prospective customers in each state to carry out geospatial planning and identify the optimal balance between grid, mini-grid, and stand-alone off-grid electrification solutions. This approach will enable the GoS to design cost-effective interventions, which are essential in the present sector context. The GoS can also strengthen its tracking and monitoring for electricity access in Sudan. One way to do this is to integrate an MTF for energy access in its national census. The MTF classifies energy access from Tier 0 to Tier 4 instead of using the dichotomous on-grid and non-grid classification. The inclusion of MTF in the census would allow the GoS to effectively track its progress toward universal access to energy, as stipulated in SE4ALL.

Figure 3.3: Geospatial Map of Sudanese Grid and Population Settlements



Source: World Bank, based on data provided by Sudanese Electricity Distribution Company
Note: The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of the World Bank Group, a judgement on the legal status of any territory, or any endorsement or acceptance of such boundaries.

69. **On the basis of the overall electrification plan, the GoS would need to update the least-cost development plan for the grid expansion.** Sudan's most recent least-cost development plan dates to 2012 and needs to be updated. The update would need to consider sector developments and actual investment decisions made since 2012 and the financial resources that are realistically available to Sudan. Grid expansion consistent with the LCP is important to ensure that investments are cost-effective and sector costs are therefore not expanding in an uncontrollable manner.

70. **A preliminary least-cost generation plan suggests that approximately US$700 million can be saved between 2019 and 2023 by aligning the investment to least-cost option.** The least-cost modeling has found that solar and wind generation have sizable potential and could account for 1,610 MW — 20 percent of installed capacity, or 10 percent of annually generated energy. Power imports from Ethiopia and Egypt are to be maximized for lowering the cost of electricity supply. The use of liquid fuels, such as HFO and diesel, will be reduced substantially over time. The cost saving is a combination of avoided fuel use and deferred capital investments to meet the demand. More detail of the least-cost analysis is provided in Annex 6.

Table 3.2: 2023 Installed Capacity with Least-cost Option

	Capacity (MW)			Generation (GWh)		
	Least-cost Plan	GoS Plan	Difference	Least-cost Plan	GoS Plan	Difference
Thermal						
Coal	600	600	0	4,468	4,730	−262
Coke	110	110	0	819	819	0
Diesel	99	99	0	0	0	0
HFO	2,438	3,668	−1,230	4,725	6,023	−1,298
Light fuel oil (LFO)	580	1,030	−450	938	401	537
Renewable						
Hydro	1,974	1,974	0	11,412	11,412	0
Solar	810	660	150	1,539	1,254	285
Wind	800	240	560	1,265	380	885
Import						
Ethiopia/Egypt	500	390	110	2,799	2,946	−147
Total						
	7,911	8,771	−860	27,965	27,965	0

71. **It is important that planning be institutionalized and implemented.** An integrated least-cost electrification and expansion plan, reflecting the increase of access as well as traditional generation expansion planning, would need to be developed. This will require consultation with MoWRIE's water department (to optimize the use of water), the Ministry of Petroleum and Gas (to optimize the use of fuels), and the MoFEP (to optimize financial resources and engage private sector investment). The expansion plan would need to be regularly reviewed and updated based on changes in the prices of technologies and fuel, as well as other external factors. It is therefore important that MoWRIE develops in-house capacity for regular updating of the plan. This will require MoWRIE staff with economic/financial analysis expertise, as well as specialized software. It is also critical that any new investments implemented are consistent with the least-cost expansion plan.

Optimizing Cross-border Trade

72. **Sudan has cross-border trade opportunities with Ethiopia and Egypt.** Specifically, there are three existing and planned interconnections between the three countries: (a) Sudan-Ethiopia interconnection with 200 MW capacity in operational condition; (b) Sudan-Ethiopia planned interconnection with 1,000 MW capacity, which does not have confirmed financing; and (c) Sudan-Egypt interconnection with 300 MW capacity, which is under construction and expected to start commercial operation in 2019.

73. **Increased use of these interconnections can help Sudan save US$200 million annually in the short term.** The interconnection with Ethiopia operates under a PPA allowing for a firm capacity import of 100 MW at the price of US¢5 per kWh. This is a very attractive price given that the marginal fuel cost of domestic thermal generation is US¢15 per kWh. Reportedly, the commercial utilization of the interconnection was on average less than 40 percent of the firm PPA quantity in 2017 due to the lack of dynamic interconnection study, which is required to ensure system stability as import volumes increase. The interconnection with Egypt is close to being completed. However, as of February 2019, the two countries were still negotiating the PPA. As long as the price that the countries agree under the PPA is below the marginal cost of Sudan's domestic electricity generation, power trade with Egypt will generate net economic and financial savings for Sudan. If both interconnections are used at 75 percent of their respective capacities, Sudan is estimated to realize annual savings of US$118 million from the increased

power imports from Ethiopia and US$79 million from the imports from Egypt, assuming PPA price of US¢10 per kWh[10].

Table 3.3: Impact of Imports on Cost of Supply

	Capacity (MW)	MWh	Fuel Savings (US$, millions)	Import Cost (US$, millions)	Net Saving (US$, millions)
Ethiopia	200	1,314,000	183.96	65.7	118.26
Egypt	300	1,971,000	275.94	197.1	78.84
Total			**459.90**	**262.8**	**197.10**

74. **The GoS needs to undertake measures to increase the use of interconnections and realize the associated cost savings.** Specifically, the National Dispatch Center would need to carry out a system dynamic study for the Sudan-Ethiopia interconnection to establish the preconditions for maintaining system stability with increased import. Based on this study, the GoS may need to make small investments in Sudanese infrastructure to address congestion and other constraints that may hinder the full utilization of the Ethiopia interconnection. The GoS could also negotiate a PPA for medium- to long-term import contracts with Ethiopia and Egypt, potentially with firm take-or-pay thresholds and step-up or step-down options. To do so, Sudan could actively participate in and contribute to the promotion of regional electricity cooperation within the framework of the EAPP.

Increasing Renewable Energy utilization

75. **Sudan has sizable and largely untapped renewable energy potential.** The country is endowed with significant hydro, solar, and wind resources, as well as the potential for geothermal. Other than using some of its hydro potential (2,000 MW), Sudan has realized a very limited share of its renewable energy potential; attempts to engage renewable IPPs in the past did not materialize due to complex procedures and the lack of market understanding.

76. **Sudan's electricity system can accommodate a significant amount of intermittent renewable energy capacity in the short term.** The use of solar and wind power generation is unlikely to destabilize the system in the short term. The exact grid integration capacity depends on the available capacity for storing energy, which in Sudan is ensured through hydro power plants that have a reservoir; an integration of 1,600 MW solar and wind by 2023, as suggested by the LCP, is considered to be feasible. The capacity of the Sudanese power system to absorb intermittent energy on a large scale in the medium term will require careful examination in the context of least-cost planning and its implementation.

77. **The cost of solar and wind power generation is estimated to be roughly half that of thermal generation and could result in savings of almost US$100 million annually.** Based on international experience, the full cost of renewable energy is presently in the range of US¢8 per kWh for solar PV IPPs of medium size and less than US¢7 per kWh for wind IPPs with good quality wind, which is the case in several locations in Sudan where wind velocity is above 7 m/s. When these technologies are financed by the public sector through concessional financing, the cost is usually less than US¢6 per kWh for solar PV and US¢5 per kWh for wind power; however, they require more government fiscal resources. These generation costs compare very favorably with Sudan's marginal generation costs of US¢14 per kWh for thermal generation based on imported HFO and diesel. The reduction in generation cost, assuming Sudan develops 400 MW of solar PV and 150 MW wind power potential within the coming two years, would be US$97 million per year after Year 2, according to Table 3.4.

[10] This is a hypothetical figure – the actual price has not been agreed yet.

Table 3.4: Cost Savings from Accelerated Development of Solar PV and Wind Generation Capacity

	Capacity (MW)	Load factor (%)	Generation (MWh)	Full cost renewable PPP (USD/kWh)	Full cost renewable Public sector financing (USD/kWh)	Full cost of production PPP (million USD)	Full cost of production Public sector financing (million USD)	Fuel saving (million USD)	Net savings PPP (million USD)	Net savings public sector (million USD)
Solar PV	400	20%	700,800	0.08	0.06	56,064	42,048	98,112	42,048	56,064
Wind	150	35%	459,900	0.07	0.05	32,193	22,995	64,386	32,193	41,391
Total	**550**		**1,160,700**			**88,257**	**65,043**	**162,498**	**74,241**	**97,455**

78. **Given the macroeconomic and sectoral situation in Sudan, the development of solar and wind power is likely to initially require significant public support in the form of financing and credit enhancements.** Given the significant opportunity cost associated with each year of delaying the deployment of solar and wind resources in Sudan (US$100 million annually, as indicated above), Sudan would need to define an adequate partnership framework between public and private sectors that can enable the development of solar and wind potential at scale and in a sustainable manner. Initially, under this framework, larger public sector support in the form of financing and assumed risks may be necessary given the difficult macroeconomic situation of the country and the lack of a successful track record implementing IPPs. Over time, the required public support should decrease as the macroeconomic and sectoral reforms improve the investment environment and Sudan establishes a track record of working in partnership with the private sector.

79. **Solar and wind power projects have high financial viability.** For a 400 MW solar and 120 MW wind program, assuming a 12 percent discount rate, the payback is estimated to be four years for the entire program, with the payback for solar at 4.8 years and the payback for wind at 3 years. The difference in payback between solar and wind is due to the higher load factor of wind and slightly higher cost per kW of installed capacity.

Table 3.5: Payback Time of Renewable Energy Program

	Capacity (MW)	Load factor (%)	Fuel saving (million USD)	Capital cost per kW installed (USD/kW)	Capital cost (million USD)	Net annual benefit excluding financing costs (million USD)	Pay-back time @ 12%
Solar PV	400	20%	98	800	320	91	**4.8**
Wind	150	35%	64	950	143	60	**3.0**
Total	**550**		**162**		**463**	**151**	**4.0**

80. **The GoS should undertake several steps to implement solar and wind power projects.** These steps include completing feasibility studies and site-specific measurements for potential sites; identifying the appropriate structure for public and private participation; launching a few pilot projects to test market appetite and allow the GoS to gain experience by engaging qualified transaction advisers; streamlining and standardizing the procedures for engaging IPPs consistent with the new PPP Act; and strengthening GoS capacity in legal issues, financial analysis, cost-benefit analysis, and other aspects of PPPs.

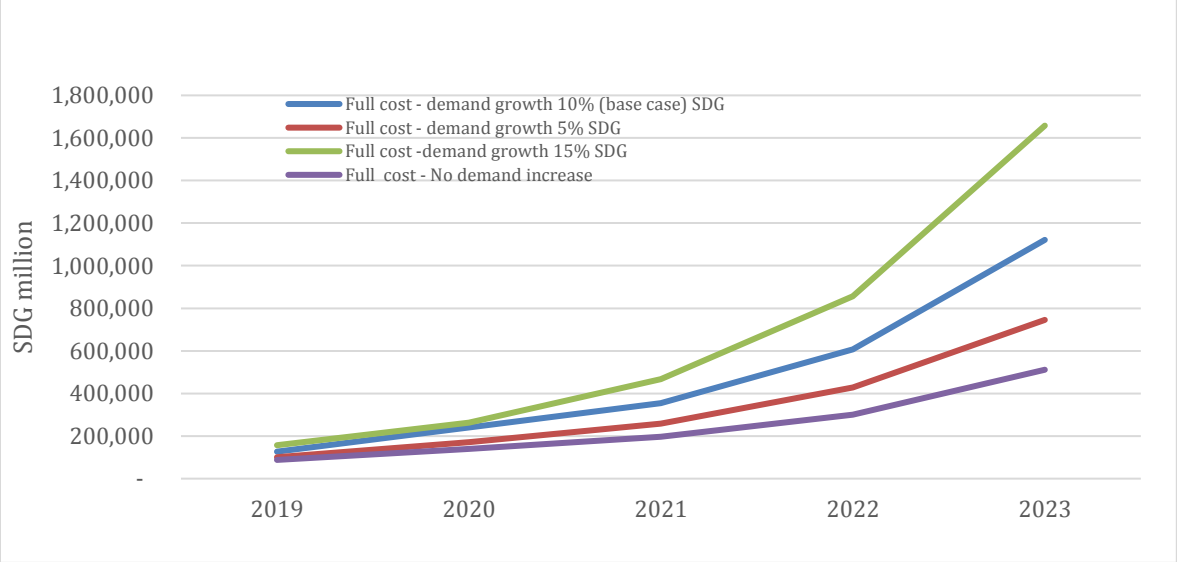
Managing Demand through Energy Efficiency

81. **A holistic approach to energy efficiency is required to contain large and increasing energy consumption and manage peak demand.** As discussed earlier, Sudan's current levels of electricity consumption and demand growth are not sustainable. To manage electricity consumption and peak

demand, it would be useful to pursue a combination of both supply- and demand-side energy-efficiency measures. Supply-side measures would involve increasing the efficiency of generation plants to reduce losses in transmission and distribution networks. A non-exhaustive list of supply-side measures could include using high-efficiency transformers, expanding line capacity, optimizing voltage levels, improving network reconfiguration, switching off redundant transformers, and balancing three-phase loads. Demand-side management could be also considered for energy savings and for shifting the consumption from peak to off-peak hours; such a shift would reduce the need for large investments in generation and network infrastructure to satisfy peak demand. The energy-efficiency measures should be planned and phased in the context of integrated sector least-cost planning.

82. **Managing demand growth can significantly reduce the sector cost.** As shown in Figure 3.4, curving the demand growth to 5 percent will reduce the sector cost by 30 percent; keeping the demand at 2018 levels can halve the sector cost compared to the base case scenario. The cost reduction is the result of avoided fuel cost and capital investment to meet the growing demand. On the other hand, higher demand growth, such as 15 percent a year (in line with SEDC projections), will result in increased cost of about 50 percent by 2023. Potential demand-side energy-efficiency measures would include promoting the use of energy-efficient appliances such as air conditioners and light bulbs through the application of energy-efficiency norms and standards, and improving access to finance and information for efficient equipment. Improved building design, such as the use of reflective roofs and better insulation, may offer low-cost opportunities to reduce cooling needs and therefore reduce electricity demand. A more detailed assessment of demand-side energy-efficiency measures and their impact would need to be carried out to identify high-impact and economically and financially viable measures. The demand-side energy-efficiency measures are most effective when deployed in conjunction with tariff adjustment, which creates better incentives for customers to conserve energy while helping to mitigate the impact of tariff adjustments on customers.

Figure 3.4: Impact of Demand Growth Management on Sector Cost



Source: World Bank Staff Calculation

83. **If the sector's access to finance deteriorates, the sector may need to consider measures to reduce demand in absolute terms to maintain the quality of service.** Given the ongoing economic crisis and the GoS's heavily constrained access to external financing, there is a risk that the GoS cannot sustain

the current subsidy level for fuel and capital investment. This inability would create fuel shortages and constrain thermal generation output. In such a case, the sector would not be able to meet the demand, resulting in planned or unplanned load shedding, with the quality of electricity service deteriorating. Demand-side management measures in combination with appropriate price signals could potentially reduce the demand to mitigate the negative impact on the quality of service.

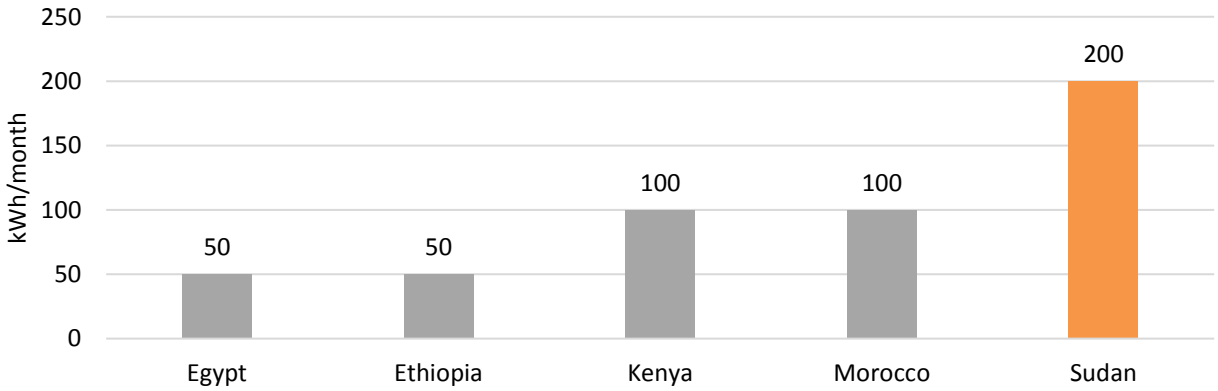
3.2: Measures to Increase Revenues

Reducing the Social Tariff Threshold

84. **The threshold for social tariff in Sudan is high and enlarges the sector's operating losses and required subsidy.** Contrary to the aim of the policy, the social tariff is not effectively supporting poor households. At the current threshold of 200 kWh per month, roughly half of residential customers fall into the social category, which is excessively broad. In addition, most of these customers are likely to be urban and belong to a relatively well-off segment of the population, given that 60-70 percent of the population does not have access to electricity. As a result, the lifeline tariff benefits a large number of consumers with higher income at a significant loss of revenue to the power sector.

85. **Reducing the threshold for social tariffs to 100 kWh could increase sector revenues by US$6 million annually while achieving the goal of the social policy instrument, which is to protect poor households.** The threshold for the social tariff should be at the subsistence level, which SE4ALL defines at 30 kWh per month. The social tariff threshold in Sub-Saharan Africa ranges from 30 kWh to 100 kWh per month (Figure 3.5). Sudan could consider a phased approach for reducing the threshold. The GoS could immediately reduce the threshold to 100 kWh per month, followed by a reduction of the threshold to 50 kWh over five years, which is the current average in Sub-Saharan Africa. The impact of such an adjustment on poor households is likely to be negligible. A typical poor (lowest quintile) household with grid access in Sudan consumes 200 kWh per month. The social tariff threshold adjustment from 200 kWh to 100 kWh would increase the household bill to SDG 11 per month (the price for the 100-200 kWh portion will increase by SDG 0.11 per kWh). This is only 0.15 percent of monthly household expenditure, which is SDG 7,000. At the same time, this adjustment would increase sector revenue by SDG 300 million or US$6 million per year.

Figure 3.5: Social Tariff Threshold in Selected Sub-Saharan African Countries



Source: World Bank

Adjusting Tariffs

86. **Sudan's electricity tariffs need to be put on an upward adjustment trajectory.** If Sudan aims for full operational cost recovery by 2028, the average end-user tariff would need to increase significantly

from the 2017 level of US¢1.5 per kWh to US¢11.5 per kWh by 2028. This change would translate into an annual tariff increase of 20 percent over 10 years, assuming that the cost-reduction measures discussed earlier are also implemented.

87. **However, the tariff adjustment necessary for reaching operational cost recovery is extremely sensitive to external factors such as the exchange rate and domestic inflation.** Given the sector's dependence on imported fuel for thermal generation, continued devaluation of the Sudanese pound can potentially offset the sector's efforts at cost reduction and revenue increase. The international good practice is to introduce automatic adjustment mechanisms so that changes in external factors are reflected in the tariff. However, given the hyperinflation in Sudan, such an adjustment may not be feasible. For this reason, cost recovery will remain a moving target in the medium term in Sudan.

88. **The GoS may set an interim tariff target to guide the short-term tariff transition.** For example, an average tariff of SDG 1.2 or US¢2.6 per kWh in five years could be expected to enable the sector to recover 50 percent of the operational costs under certain external conditions.[11] Although this level is approximately three times the current tariff level, it would still be one of the lowest tariff levels in Sub-Saharan Africa and would keep the tariffs in the affordability range for the Sudanese people. After achieving the interim target, the GoS could revisit the target, taking into account evolving external factors outside the sector's control to determine the next course of action. Such an approach would allow the sector to focus on factors within the sector's control in its effort to achieve cost recovery.

89. The GoS can mitigate the impact of a rising tariff through frequent and incremental increases. In the past, MoWRIE reviewed the tariff annually at the beginning of the year; the last revisions were in 2016 and 2018. International experience suggests that more frequent revisions, such as semiannual, quarterly (as in Uganda), or even monthly, allow consumers to adapt to new tariff levels more effectively. Such an approach allows the government to pause the tariff hike if a significant negative impact on the public is observed.

Table 3.6: Percentage of Average Tariff Adjustment Needed to Achieve Fivefold Increase in Five Years

Annual (5 Adjustments)	Semiannual (10 Adjustments)	Quarterly (20 Adjustments)	Monthly (60 Adjustments)
38	17	8	3

90. **The tariff increase is unlikely to significantly affect the poor.** As part of this diagnostic, a PSIA was carried out using household survey data and the subsidies simulation (SUBSIM) model[12] to assess the impact of tariff increases on households, especially poor households, as summarized in Figure 3.6. The impact of the price change is the difference in household well-being[13] (of the same year) between the current tariff level and the price change suggested in each scenario. The PSIA indicates that the direct effects of tariff increases are relatively small since electricity accounts for a small share of household

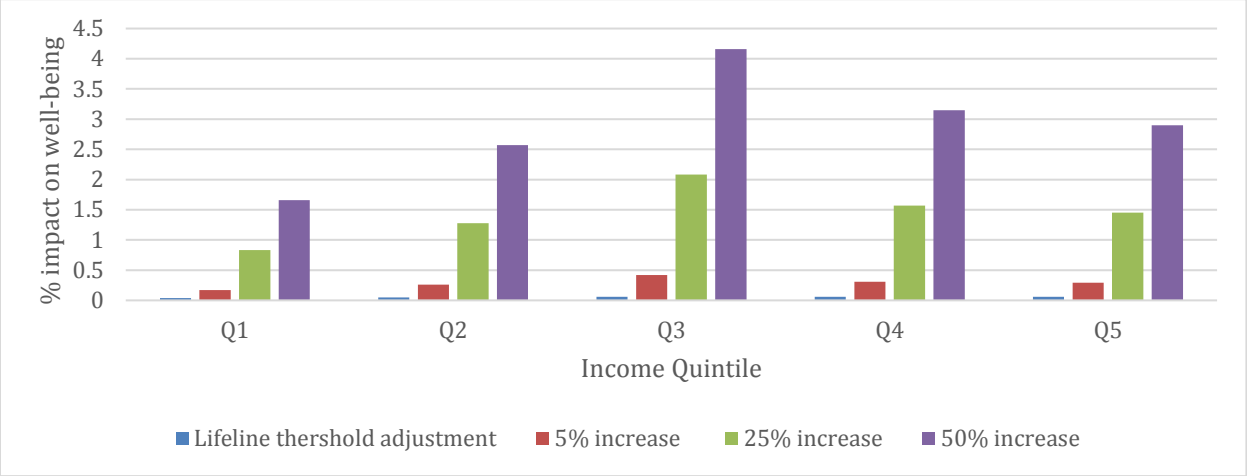
[11] This assumes an exchange rate of US$1 = SDG 47.5, constant international fuel price, and implementation of various cost-reduction measures.

[12] SUBSIM measures changes in well-being as changes in total consumption (as approximated by expenditure). Moreover, SUBSIM uses a marginal approach, meaning it assumes the total change in expenditure is approximated by the change in expenditure on the good whose price changes. See Araar and Paolo, 28.

[13] Household consumption is approximated by household expenditure on electricity. The calculations are made based on data from the NHHBPS 2014 household survey. Expenditure is estimated as monthly expenditure in 2014, updated by inflation using the IMF World Economic Outlook Database.

expenditure (less than 5 percent on average). Depending on the scenario, the total direct loss for households would range from 0.06 percent, when only the SDG 0.15 lifeline changes from 200 kWh to 100 kWh per month, to 3.14 percent in the scenario when the lifeline of SDG 0.15 decreases from 200 kWh to 100 kWh per month and the rest of the tariffs are increased by 50 percent. The impact of the social lifeline threshold adjustment is negligible at an average loss of 0.05 percent, with the smallest impact seen on the poorest quintile. For all scenarios, the impact on the poor was less than half the impact on the middle class.

Figure 3.6: Impact of Tariff Increase on the Well-being of Different Income Quintiles



Source: World Bank based on NHHBPS 2014

91. **Urban middle-income households are likely to be most affected by tariff adjustments.** The GoS should thus target this group with an effective information campaign to ensure public acceptance of tariff reforms. The PSIA indicates that the largest impact of tariff reforms is likely to be felt by urban middle-income households (the third income quintile). The majority of the poor (the first quintile and, to a large extent, the second quintile) do not have access to electricity; for those connected, the consumption level is relatively low: 177 kWh per month for the first quintile and 208 kWh per month for the second quintile. Therefore, the direct tariff-adjustment impact on the poor would be limited. The richer households (in the fourth and fifth quintiles) will be paying higher tariffs, but their high income levels would mitigate the impact of the increase. In terms of the absolute amount (not percentage), the impact would be the greatest on the richer segment of the Sudanese population. The urban middle-income population is likely to be the most vocal and organized in contesting tariff reform. A communications campaign would need therefore to effectively target the middle class. In addition, the GoS could use a part of the subsidy reduction to strengthen its social safety net, such as the Social Initiative Program (SIP). Strengthening and scaling up such a program in conjunction with tariff adjustment is likely to mitigate the tariff reform impact on the poor and also increase general public acceptance of the reform. Part of the middle-income population may also be eligible for such support.

92. **Timing of tariff adjustment needs to be carefully assessed.** Tariff increase in a short timeframe would likely allow greater cost recovery of the sector, but would have a more significant impact on people than adjusting tariff over the medium- to long-term. This impact may create political pushback against further tariff increase. As noted above, a strengthened social safety net can play an important role in mitigating impact. On the other hand, tariff reform in a longer timeframe would reduce the shocks felt by people and also allow GoS to take long-term cost-reduction measures. However, such an approach would require fiscal resources to sustain tariff underpricing in the medium term.

93. Beyond the direct impact on households, certain industries and businesses could be impacted by increased electricity tariff. Energy-intensive industries and businesses – such as ice-making factories, cold store, private schools/hospitals, workshops, and waterworks – could be affected by increased tariff. Assessing the magnitude of that impact on the Sudanese economy will require a dedicated analysis. However, in general, the cost of electricity constitutes a small portion of business operation, and therefore the overall impact of tariff increase is likely to be small.

3.3: Measures to Facilitate Reforms

Accompanying Reforms with Public Communication

94. **Currently, public acceptance or support for tariff increase in Sudan is likely to be low due to several factors.** First, because of Sudan's legacy as an oil-producing nation, the public is likely to be used to low-cost electricity and broader energy services. Second, it is likely that the ongoing economic crisis and public unrest in the country are undermining confidence in the Sudanese authorities and reducing willingness to accept any price increase. Similar cases have been observed in other countries (for example, Egypt, Tunisia, Jordan, and Nigeria), where the public had very limited understanding of energy sector realities and challenges. In those countries, the public also believed that the country was rich in energy (for example, oil and gas) but that the energy was expensive because the government was not managing the sector well. This belief prevailed despite the fact that energy was heavily subsidized. In many of these countries, well-designed communications campaigns facilitated a shift in public opinion toward support of subsidy reform. The campaigns were based on high-level government commitment, public opinion research, stakeholder mapping, and political economy analyses. The opposite approach — a rushed effort to reform subsidies without a well-prepared communications campaign — often backfired during the reform implementation, as was the case in Tunisia.

95. **Tariff reform is essential for sector recovery in Sudan, and the reform needs to be carefully and strategically communicated to the public.** The GoS's communications or public relations teams in the electricity sector can play a key role in the information campaign. A shared vision of the communications program and its implementation among all communications/public relations teams in the power sector and other associated sectors must be in place to avoid duplication or contradictory messages. The communications campaign can raise awareness about the current magnitude of the subsidy and the consequences of allowing the status quo to persist, including lost opportunities to use resources to improve other key public services such as health, education, transport, and water supply. It can showcase the roles that sector authorities are playing to keep electricity affordable (for example, development of domestic renewable electricity and power trading) and improve the reliability and quality of the electricity supply. Such a campaign can also educate the public about reducing electricity consumption through energy-efficient behaviors that could lower their monthly bill.

96. **The communications campaign should be underpinned by solid research and supported by a specialized firm.** The GoS would need to form a sector-wide communications team to prepare a communications strategy, engage a specialized communications firm to assist in this effort, conduct a public opinion survey and stakeholder mapping exercise to inform the strategy, prepare the strategy and necessary materials, and launch the communications campaign.

Improving Institutional Arrangements

97. **The GoS should also clearly delineate the roles and responsibilities for policy-making, regulation, and operational management to facilitate implementation of reforms.** There are currently large numbers of institutions involved in the operation of the electricity sector, leading to numerous interface problems (increased operational and transaction costs) and various complexities in terms of

administration, coordination, and management. The sector has five companies — thermal, hydro and renewable, transmission, distribution, and holding. There are overlapping responsibilities among MoWRIE, ERA, DIU, and SEHC. Clarifying the roles and responsibilities of sector companies and oversight institutions will improve the efficiency of sector operation and decision-making.

98. **The electricity sector needs commercialization and corporatization of its utilities to achieve increased autonomy for companies in their financial and operational decision-making.** The current arrangement, in which all budgetary appropriations and sales revenue are pooled into SEHC for redistribution to the sector companies complicates sector financial flows and may contribute to operational inefficiencies. The arrangement provides limited incentives for prudent cost control and revenue-enhancement measures. The commercialization of sector companies should include (a) commercial and contractual transactions between the value chains of generation, transmission, and distribution under the negotiated tariff; (b) delegation of investment decisions to sector companies; and (c) external auditing of financial statements of sector companies following international accounting best practice.

99. **The role of the ERA needs to be more clearly defined and strengthened, particularly with regard to tariff-setting.** In the current institutional context of the sector, the ERA's role is to recommend tariffs to MoWRIE in consultation with the sector companies. However, the ERA has been unable to complete a tariff study initiated in 2015 due to a shortage of technical capacity and financial resources. Consequently, the sector has been unable to implement adequate tariff schedules that are based on sector technical, economic, and distributional analyses. The ERA's capacity needs to be strengthened if it is to properly review and recommend tariffs and monitor the sector's technical and financial performance.

Annexes

Annex 1: List of Current and Prospective Generation Assets in Sudan

Name	Year	Type	Technology	Fuel	Installed Capacity (MW)
On-Grid					
Merowe	2009	Hydro	—	—	1,250.0
Kosti	2008	Thermal	Steam turbine	Crude oil	500.0
Garri 1 and 2	2002	Thermal	Combined cycle gas turbine	LDO/HCGO	469.0
Garri 4	2006	Thermal	Steam turbine	SC	110.0
Mahmoud Sharif	1985	Thermal	Steam turbine	HFO/HCGO	380.0
Mahmoud Sharif	2016	Thermal	Gas turbine	LDO/HCGO	150.0
Roseires	1971	Hydro	—	—	280.0
Port Sudan	1983	Thermal	Diesel engine	DO/LDO	40.0
Jabal Awlia	2005	Hydro	—	—	30.4
Sinnar	1962	Hydro	—	—	15.0
Khashm El Girba	1965	Hydro	—	—	17.8
E Obied	1987	Thermal	Diesel engine	DO/LDO	12.7
Seitat and Upper Atbara	2018	Hydro	—	—	320.0
Off-Grid					
Al-Fasir	2002	Thermal	Diesel engine	LDO/DO	31.0
Nyala	1985	Thermal	Diesel engine	HFO/DO/LDO	32.0
El-Ginena	1989	Thermal	Diesel engine	DO/LDO	10.0
Kadogli	2004	Thermal	Diesel engine	DP/LDO	8.0
El-Nohod	2004	Thermal	Diesel engine	DP/LDO	8.4
El-Diain	2004	Thermal	Diesel engine	DO/LDO	7.5
Zalingei	2015	Thermal	Diesel engine	LDO	2.6
In Pipeline					
Garri 3	2019	Thermal	Gas turbine	HFO	561.0
Port Sudan	2019	Thermal	Gas turbine	HFO	376.0
Al-Fasir	2019	Solar	PV (hybrid with diesel)		5.0
El Dein	2019	Solar	PV (hybrid with diesel)		5.0
Darfur	2019	Thermal	Diesel engine	HFO + LDO	150.0
Garri 3 upgrade	2021	Thermal	Combined cycle gas turbine	Exhaust flue gas	240.0
Port Sudan upgrade	2021	Thermal	Combined cycle gas turbine	Exhaust flue gas	1175.0
Al-Bagir	2021	Thermal	Combined cycle gas turbine	HFO	350.0
Al-Fulah	2021	Thermal	Gas turbine	Gas	450.0
Dongola	2021	Wind	—	—	1.0
Red Sea	2022	Thermal	Steam turbine	Coal	1,000.0
Elshaheed	2022	Thermal	Gas turbine	HFO and LDO	350.0

Note: DO: Diesel Oil (70 percent LDO + 30 percent HFO).

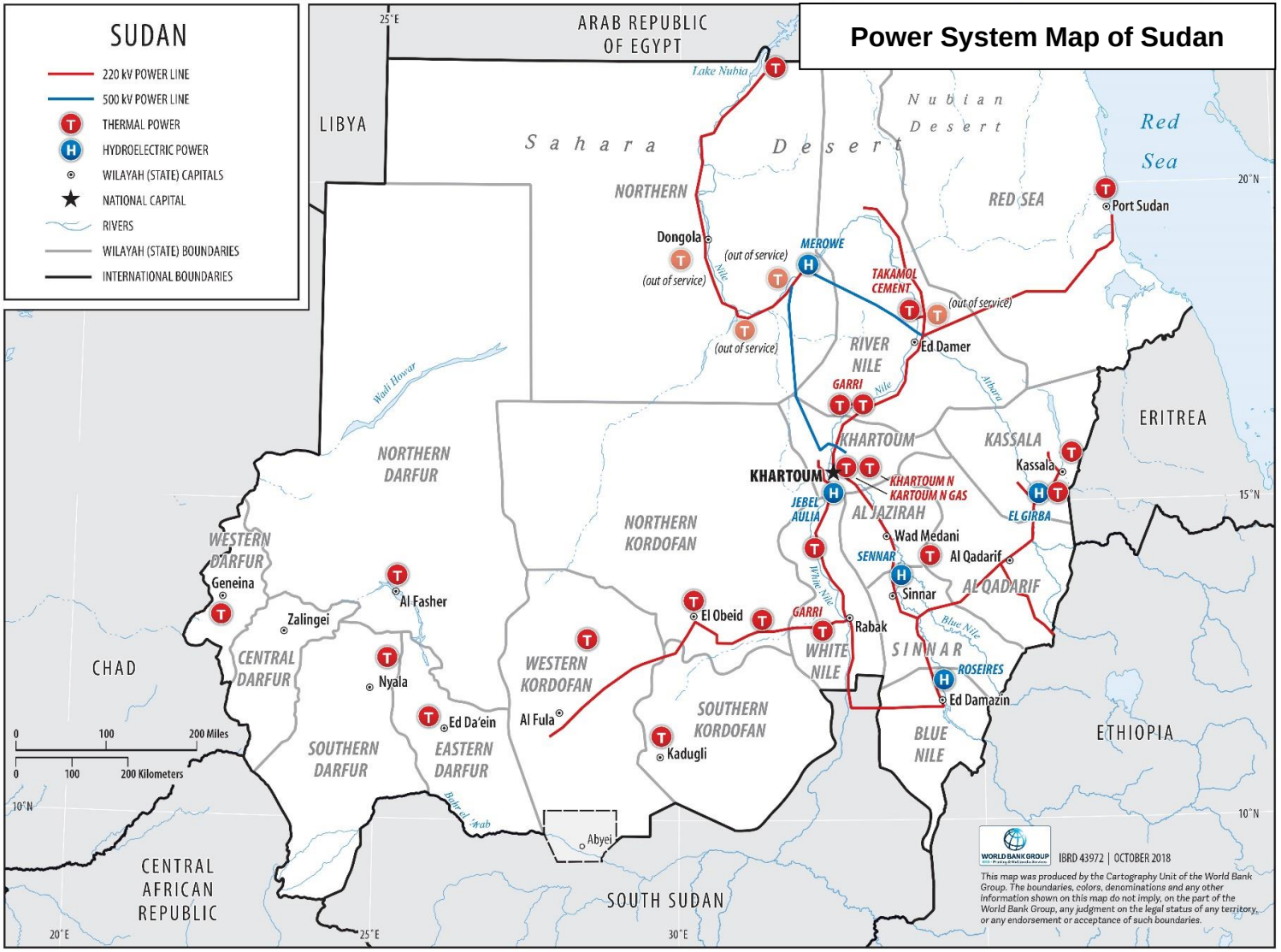
Annex 2: Sudan's Electricity Tariff Structure

No.	Sector/Consumption kWh	SDG/kWh (2018)	US$/kWh (US$1 = SDG 47.6)
1	**Domestic tariff**		
	From 1 to 200	0.15	0.003
	From 201 to 400	0.26	0.005
	From 401 to 600	0.32	0.007
	From 601 to 800	0.52	0.011
	From 801 to 1,500	0.85	0.018
	Above 1,500	1.60	0.034
2	**Agricultural tariff**		
	Up to 50 HP, National and Research and Training Projects	0.16	0.003
	More than 50 HP	1.60	0.034
3	**Industrial tariff**		
	Medicine industries	0.18	0.004
	Other industries	1.60	0.034
	Cold stores and ice		
	• From 1 to 400	0.34	0.007
	• More than 400	0.85	0.018
4	**Commercial tariff**		
	From 0 to 200	0.34	0.007
	From 201 to 300	0.85	0.018
	From 301 to 400	1.00	0.021
	More than 400	1.60	0.034
5	**Service tariff**		
	Water works and holy places	0.33	0.007
6	**Schools**		
	Government schools	0.33	0.007
	Private student hostels	0.33	0.007
7	**Private hospitals and universities**	0.75	0.016
8	**Government**		
	Government departments	0.70	0.016
9	**Tourism (hotels)**	0.85	0.018
10	**Communications companies, embassies, and organizations**	1.60	0.034

Annex 3: Electricity User Profile in Sudan

Sales (MWh)	2015	2016	2017
Residential	5,973,123	6,693,310	7,352,511
Industrial	1,512,258	1,794,317	2,003,377
Commercial	1,378,184	1,473,870	1,568,314
Agricultural	650,664	718,924	873,881
Government	1,034,352	1,087,877	1,163,088
Company facilities	32,033	27,232	25,445
Total	**10,580,614**	**11,795,530**	**12,986,616**
Revenue (SDG, millions)			
Residential	1,212,059	1,422,690	2,145,636
Industrial	257,911	305,799	429,186
Commercial	468,680	570,926	1,059,828
Agricultural	104,196	115,039	152,358
Government	588,577	610,293	658,389
Total	**2,631,423**	**3,024,747**	**4,445,397**
Number of customers			
Residential	2,020,878	2,096,756	2,218,516
Industrial	1,852	2,006	2,216
Commercial	217,565	227,591	235,989
Agricultural	17,772	19,422	21,486
Government	44,734	46,025	50,256
Internal consumption	257	265	266
Total	**2,303,058**	**2,392,065**	**2,528,729**

Annex 4: Power System Map of Sudan



Annex 5: Description of Key Sector Entities

1. **MoWRIE** was created in 2012. It supervises all electricity sector companies, appointing key staff, allocating vital financial support to SEHC, and controlling investment decisions through the direct management of financing of all capital investment. MoWRIE also supervises ERA. Other key responsibilities of MoWRIE include:

- Approving general policies and rules for power generation, transmission, and distribution;
- Negotiating and concluding any agreement related to power imports and exports;
- Approving sector technical specifications;
- Setting electricity tariffs upon recommendation of ERA; and
- Supervising the activity of sector institutions (particularly DIU and SEHC), a function not listed in the 2001 act.

MoWRIE has limited planning and implementation capacity. It has to make investment decisions based on the availability of financing, with little consideration for the sector development plan. MoWRIE is making efforts to improve its capacity to organize and develop renewable energy projects to be funded by the private sector; this work is taking place in consultation with the MoFEP and the Ministry of Investments.

2. **SEHC** was created in 2016 and is fully government controlled. It delegates operational responsibilities to its subsidiaries but retains a major role in allocating to subsidiaries revenues collected by the SEDC (topped up by the GoS budget allocation) and in investment decisions and financing. The SEHC also negotiates transfer prices between power sector entities, which are its subsidiaries, and is responsible for power dispatch.

3. **SHGC** is responsible for the O&M of all hydro plants and dams. It has no authority over investment decisions, which in principle are made at the SEHC level, based on the MoWRIE development plan for hydro. In practice, investment decisions are made by DIU, which is also responsible for implementation. (For minor investments not handled by DIU, procurement is overseen by the SEHC and implemented under its supervision.) Like all subsidiaries of the SEHC, the SHGC is not responsible for its finances, apart from implementing its annual budget, nor does it supervise construction. The SHGC supplies the electricity it produces to SETCO at the transfer price set by the SEHC and MoWRIE in consultation with ERA. Created in 2016, the SHGC plants generated 8,052,178 MWh in 2017.

4. **STPG** is the subsidiary of the SEHC responsible for managing the construction of thermal plants and their operation, as well as the supervision of investments, which are decided at SEHC level. Created in 2016, the STPG's function is essentially technical, as investment financing and procurement are handled by the SEHC. The STPG supplies the electricity it produces to SETCO at the transfer price set by the SEHC and MoWRIE in consultation with ERA. Presently, the transfer price to SETCO is SDG 0.0783 per kWh and does not include the fuel cost, which is paid directly to fuel suppliers by the government. In 2017, the volume of energy sold by the STPG was 6,193.70 GWh.

5. **SETCO** is responsible for the management, maintenance, and operation of the power transmission system and for supervising the construction of transmission infrastructure. Like the STPG, SETCO was created in 2016, and its role is mainly technical. It is not the power dispatcher. SETCO purchases electricity produced from grid-connected thermal and hydropower plants, acting in practice as a single buyer rather

than as a transmission service provider; it sells at a uniform price to the SEDC with a markup of SDG 0.0124 per kWh to cover transmission costs. The volume of electricity SETCO transmitted in 2017 was 14,638.83 GWh.

6. **SEDC** is the SEHC subsidiary in charge of power distribution, managing the national distribution grid and also some isolated grid systems. In practice, it is the sole distributor in Sudan, though its monopoly is not enshrined in law. Created in 2016, the SEDC had a total of 2.5 million clients as of 2017; all but 5,000 of those had prepayment meters. The SEDC collects electricity bills from all clients and remits the proceeds to the SEHC after deduction of its own cost of distribution. Sales in 2017 were 12,986 GWh, and distribution losses were estimated at about 15 percent, of which 6 percent were technical losses.

Distribution system extensions in isolated grid or grid-connected networks are requested by the states and financed by the GoS and consumers. The connection fee is SDG 7,000-15,000 for households. Most isolated grids are financially autonomous and are managed by states or local communities.

7. **DIU** was created in 1999 to develop, construct, and supervise the Merowe dam. Its role was extended in 2005 to cover the development and supervision of construction of all hydropower plants. Capitalizing on its experience in complex infrastructure projects, DIU is now extending outside of the electricity sector to major infrastructure projects. After completion of construction, infrastructure is transferred for operation and management to technical ministries and entities. DIU has become a powerful and highly competent unit in charge of pre-feasibility and feasibility studies, irrigation schemes, water harvesting, transport infrastructure (bridges), some housing development, financing of infrastructure (from Islamic Development Bank and Arab Funds through the MoFEP), and contracts tendering. DIU is accountable directly to MoWRIE and has the status of a corporation, with a state minister in MoWRIE appointed as its chief executive officer.

8. **ERA** is the sector regulator. Created by the Electricity Act of 2001, ERA is directly under the authority of MoWRIE and is fully funded by an annual budgetary allocation from MoWRIE; it has limited independence. ERA is currently chairing the drafting committees for the preparation of the Renewable Energy and Energy Efficiency Acts. The responsibilities of ERA include:

- Preparing electricity policy for approval by MoWRIE;
- Supervising generation, transmission, and distribution activities in accordance with sector policies and strategies set by MoWRIE;
- Acting as technical adviser to the GoS;
- Supporting potential investors in the power sector;
- Making recommendations to MoWRIE concerning electricity tariffs;
- Setting technical specifications applicable to the power sector (including power utilities and consumer electronics);
- Issuing licenses for power sector operators; and
- Supporting the implementation of environmental regulations applicable to the power sector.

Annex 6: Least-cost Analysis for Sudan's Electricity Generation

A comparison of the least-cost and government generation expansion plans in the near term (2019–2023) reveals that the former can defer US$1.65 billion of capital expenses and save US$536 million of fuel costs over the four-year period. The LCP defers liquid fuel based capacity and instead brings in additional wind and solar capacity.

1. The analysis compares an LCP optimized over 2019–2030 with the Government Plan (Gov Plan). In particular, we focus on 2019–2023 to look at the difference in CAPEX and fuel cost differences, as summarized in Table A0.1 below. There is a significant amount of CAPEX (US$1.65 billion) that could be deferred over this period. The fuel cost savings are significant: US$536 million over five years. Note that the CAPEX difference over 2019–2023 should not be added to the fuel cost difference. The CAPEX plans should be compared over a longer period for long-lived assets. The CAPEX difference over 2019–2023 simply indicates that some CAPEX during the early years could be postponed.[14] The net present value (NPV) of annualized capital cost difference over 2019–2023 is a more modest US$175.27 million if we assume that all of the generation assets have a life of 30 years and the cost of capital is 10 percent. This savings of US$175.27 million can be added to the fuel cost savings of US$536 million to yield a total savings of US$710.80 million. The average generation cost in the LCP over 2019–2023 is US¢ 0.8 per kWh lower (or 9 percent) relative to the Gov Plan.

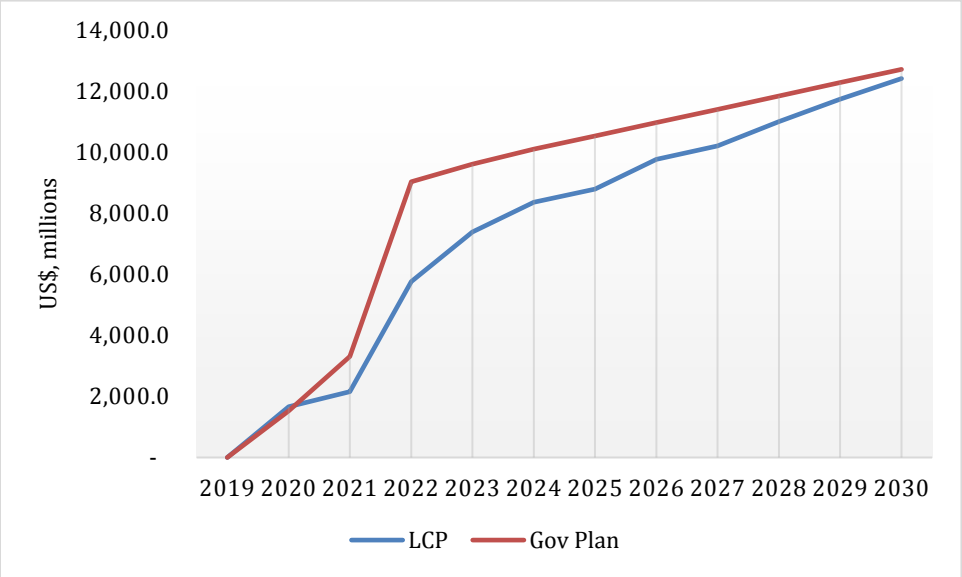
Table A0.1: Summary of Cost Savings (NPV 2019–2023 at 10 percent in US$, millions)

	LCP	Gov plan	Difference
CAPEX	5,211	6,863	32%
Fuel	5,103	5,638	10%

2. In the long run (by 2030), the total CAPEX in the LCP (US$12.4 billion) and Gov Plan (US$12.7 billion) are quite close to each other, suggesting that most of the capacity included in the Gov Plan is eventually needed but can be postponed, as has been accomplished in the LCP.

[14] It is worth noting, however, that the capital deferral will not necessarily occur every year and the LCP in fact has slightly more CAPEX in 2020 and 2023 compared to the Gov Plan. The key is that the LCP optimizes capacity *and* fuel costs together over 2019–2030 and, although it defers capital costs as much as possible, there will be a need to bring in some of the cheaper capacity early on to save fuel costs.

Figure A0.1: Comparison of Cumulative Generation CAPEX (US$, millions)



Source: World Bank staff calculation

3. Finally, a comparison of the detailed capacity and generation in 2023 reveals that:
   - Around 860 MW of capacity can be saved, primarily in the form of deferring/avoiding expensive HFO (1,230 MW) and LFO (450 MW) based capacity;
   - There is more solar (150 MW) and wind (560 MW) capacity in the LCP;
   - There is significantly lower HFO-based generation (1,298 GWh) although some of the LFO capacity needs to be run harder to produce 537 GWh additional generation;
   - There is additional 285 GWh of solar and 886 GWh of wind in the LCP; and
   - Total generation remains the same across the LCP and Gov Plan.

Table A0.2: Comparison of Capacity (MW) and Generation (GWh) in 2023

	Capacity (MW)			Generation (GWh)		
	LCP	**Gov Plan**	**Difference**	**LCP**	**Gov Plan**	**Difference**
COAL	600	600	0	4,468	4,730	−263
Import	500	390	110	2,799	2,946	−147
Coke	110	110	0	819	819	0
Diesel	99	99	0	0	0	0
Gas	0	0	0	0	0	0
HFO	2,438	3,668	**−1,230**	4,725	6,023	**−1,298**
LFO	580	1,030	**−450**	938	401	537
Water	1,974	1,974	0	11,412	11,412	0
Solar	810	660	150	1,539	1,254	285
WIND	800	240	**560**	1,265	380	**886**
TOTAL	**7,911**	**8,771**	**−860**	**27,965**	**27,965**	**0**

Annex 7: Sector Capacity Building and Technical Assistance Needs

Tariff	**Tariff reform planning:** Detailed tariff reform, including the setting of interim target, timeframe and adjustment of lifeline tariff, will need analytical support. **Public communication support:** Specialized consultant can help carry out public opinion survey and develop communication strategy to enhance public acceptance for tariff reform.
Planning	**In-house capacity for least-cost planning.** Such planning capability will allow frequent revision of sector investment plan and ensure that available financing is used for maximum benefit.
Renewables	**Training for public-private partnership**. Given Sudan's limited exposure to private investment in the sector, a fundamental training on public-private partnership, including technical, financial and legal aspects, will be useful. **Transaction advisory.** A qualified firm for transaction advisory service can work to sound out the market to assess interest in private investment in the power sector in Sudan and potentially design a competitive bidding.
Energy Efficiency	**Supply-side energy audit** can identify low-cost distribution loss-reduction opportunities. **Demand-side energy audit** can assess electricity consumption profile in various user types and identify low-cost measures to curb demand.
Electrification	**GIS-based planning.** With adequate support, GoS can develop a least-cost electrification plan to enhance electricity access. **Off-grid market development support**. GoS can learn from other neighboring countries how to scale up high-quality off-grid solutions.

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