



Empowering Sudan:

Renewable Energy Addressing Poverty & Development



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September 2020

Foreword by The Acting Minister of Energy and Mining

Sustainable and affordable energy is at the heart of Sudan's efforts to provide universal access to energy to its rural and urban citizens. Our national development priorities reflect energy's central role in poverty reduction, women's empowerment and public health improvements. We are convinced that making progress on universal energy access will also strongly contribute to progress on overall sustainable development.

This report provides a national strategic roadmap of policies and measures for Sudan that focuses on the potential of renewable energy to promote poverty reduction and sustainable development. This roadmap comes at a poignant moment in our country's history, coinciding with the beginning of a Decade of Action towards the Sustainable Development Goals, the implementation of Nationally Determined Contributions under the Paris Climate Agreement, and a global COVID-19 pandemic that is threatening to leave deep social, economic and political impacts for years to come. The roadmap seeks to seize this moment in advancing the strategic opportunities renewable energy offers to address Sudan's many development challenges.

Providing stable and affordable energy to the millions of people in rural Sudan who lack access is a development imperative. Without it, their human development is hindered, their public health is compromised, and their income-earning opportunities remain limited. Recent developments in off-grid, renewable energy technologies – with their lower-cost and greater efficiencies – suggests that the time is right to move from pilot projects to a full scale-up of these technologies while advancing new and innovative private sector business models. Sudan's international partners can play a critical role in addressing the investment risks associated with these efforts, thereby encouraging private sector investment.

The roadmap of recommended actions discussed in this report is focused on three key areas: increasing access to sustainable energy services for poverty reduction & women empowerment; accelerating structural transformation of energy sector as a means of sustainable development; and expanding energy service as key enabler for building resilience and sustainable recovery. We believe the study will have a significant contribution towards meeting the energy access goals of the SDGs.



Khairy Abdelrahman Ahmed
Acting Minister
Ministry of Energy and Mining
Khartoum, Sudan

Foreword by UNDP Resident Representative Selva Ramachandran

Renewable energy can play a pivotal role for sustainable development and act as a means for poverty alleviation. This study assesses the extent to which renewable energy has the potential for development and poverty alleviation in Sudan. Its roadmap of policies and measures provides a sound basis for expanding access to sustainable and affordable energy in rural areas for poverty eradication and the empowerment of women in Sudan.

By developing an enabling policy environment for expanding energy access; deploying decentralized renewable energy technologies; and building institutional capacity, the roadmap will facilitate a number of development outcomes. These include, among others, progress toward Goal 7 of the Sustainable Development Goals, inclusive productive enterprises for women, an effective set of policies and incentives for energy access; and improved functioning of local energy markets.

UNDP will continue to provide support for programme design and an enabling environment for implementation of the roadmap. As a partner of the Climate Investment Platform (CIP), UNDP will seek to leverage additional expertise and capabilities through the CIP network, as well as convening and mobilizing additional development and climate actors in support of the roadmap.

We thank all sector line ministries at federal and state levels, UN agencies, and our wide range of partners for their active participation during the development of this strategic roadmap. We encourage all policy makers and development partners including donors, civil society organizations and private sector to join together in helping to accelerate its implementation and expansion of renewable energy for a broader benefit of local people.

Putting poverty alleviation and women's empowerment at the core of a universal energy access agenda is essential for the future of Sudan, and offers a way to improve and empower the lives of millions.



Selva Ramachandran
Resident Representative

*United Nations Development Programme
Khartoum, Sudan*

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UNDP Sudan however, remains responsible for any errors of omission or commission and welcomes any additional constructive comments that will lead to a refinement of the report's key messages about the potential for renewable energy to advance Sudan's sustainable development and poverty reduction goals.



Executive Summary

Energy use is growing rapidly in Sudan. Traditional biomass provides most of the energy needs of the local population, especially those who live in the countryside with no access to electricity. On the other hand, electricity use has been growing at about 13% per year despite the fact that only 47% of the country's rural population is currently connected to the electric grid (IEA et al, 2020).

Sudan faces many energy development challenges brought about by high electricity subsidy levels and climate-induced impacts on hydroelectric generation which has been decreasing at a rate of about 4% per year. Improving access to modern and affordable energy is a development priority for Sudan.

The development of a national strategic roadmap of policies and measures to promote renewable energy for sustainable development and poverty reduction comes at poignant moment in the country's history. It coincides with the beginning of a Decade of Action towards the Sustainable Development Goals, the implementation of Nationally Determined Contributions under the Paris Climate Agreement.

Simultaneously, a global COVID-19 pandemic that is threatening to leave deep social, economic and political impacts for years to come, particularly in a country like Sudan that is already burdened by deep poverty and chronic conflict. The roadmap recommends measures to address each of the above development challenges.

The report has been prepared consistent with energy priorities outlined in in line with major national documents that guide policymaking in the energy sector. It is based on the outcomes of consultations organized by UNDP in response to a request by the Government for technical support in identifying and fast-tracking sustainable energy initiatives and investments.

It focuses on broad strategic themes aimed at addressing the unique sustainable energy and development challenges identified during consultations with key energy and civil society stakeholders in Khartoum.

The report is framed against a background of the strong linkages between energy, poverty, and gender in Sudan. The lack of access to energy services is both a cause and outcome of poverty. As a cause of poverty, the lack of access to energy means that income generation potential is severely limited for poor households; as an outcome of poverty, the lack of access to energy means that poor households are unable to afford goods and services that others enjoy.

Moreover, the relationships between energy and poverty have distinct gender overtones as poor women, many in female-headed households, spend much more time than their male counterparts on energy-related activities such as firewood gathering, water fetching, and cooking.

Providing renewable energy services for sustainable development poverty reduction is focused on sixty-nine (69) specific recommendations across three key themes and nine strategic areas. First, to increase access to sustainable energy services for poverty reduction and women empowerment; second, to accelerate the structural transformation of energy sector as a means of sustainable development; and third, to promote energy service as a key enabler for building resilience and sustainable recovery to all forms of development shocks.

The roadmap specifies implementation modalities for the short-term (within the next 6 months), medium-term (between 6 months and 3 years), and long-term (beyond 3 years). Table ES-1 provides an overview of the key themes and strategic priorities.

Table ES-1: Breakdown of the 69 recommended actions in Sudan’s strategic roadmap of renewable energy policies and measures for poverty reduction

Key Themes	Access to sustainable energy services for eradication of poverty in all its forms and dimensions (26)	Structural transformation of energy sector as a means for sustainable development (34)	Energy services for resilience building and sustainable recovery (9)
Strategic priorities	<ul style="list-style-type: none"> Expand universal access to modern energy services for poverty eradication to all (9) Integrate and deploy decentralized energy solutions in the development of rural areas (11) Enhance energy efficiency in urban areas and strengthen capacity of increased efficient energy in the economy (6) 	<ul style="list-style-type: none"> Strengthen institutional capacity for integrating energy in evidence-based development planning (13) Initiate a process for policy de-risking of sustainable energy investments (7) Enhance capacity for disaggregated sustainable development data and knowledge management (9) Integrate renewable energy in national development planning (5) 	<ul style="list-style-type: none"> Integrate energy services in resilience building and sustainable recovery planning and programming (4) Deploy solar energy solutions for basic and productive energy services (5)

It is important to note that the actions recommended in this roadmap is not an exhaustive prescription of sustainable energy interventions. Rather, it represents a programming framework for activities that can lead to public and private sector energy investments in Sudan while contributing to poverty reduction, especially in Sudan’s rural areas. Implementing the roadmap will accelerate the diffusion of renewable energy systems and the adoption of energy efficient technologies in Sudan and lead to poverty reduction and women’s empowerment.

The recommended actions will also enhance capacity while complementing the efforts of national agencies, the private sector, local and international development partners and the civil society. Finally, the roadmap’s focus on the implementation of sustainable energy initiatives will contribute to achieving Sudan’s sustainable development agenda and faster action toward the achievement of SDG7.





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Glossary of Terms

Biogas: A combustible gas formed by natural processes of anaerobic digestion, in which microorganisms convert organic material into a gas which has composition and combustion characteristics similar to natural gas. Biogas units are available in household, community, and industrial sizes.

Biomass: Any organic material of plant or animal origin such as wood, agricultural residues and dung that is used as a fuel.

Energy: Includes renewable sources (hydro, biomass, wind, geothermal), non-renewable sources (oil, refined oil products, natural gas) and secondary sources (electricity).

Energy access: Household access to i) a minimum level of electricity; ii) safer and more sustainable cooking and heating; iii) modern energy that enables productive economic activity; and iv) modern energy for public services.

Energy carrier: A substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes.

Energy efficiency: Using less energy (electricity, fuels) to perform the same function at the same level of quality.

Energy poverty: Absence of sufficient choice in accessing adequate, affordable, reliable, clean, high-quality, safe and benign energy services to support economic and human development.

Energy services: The desired and useful products, processes or services that result from the use of energy; for example, illumination, comfortable indoor climate, refrigerated storage, transportation, appropriate heat for cooking.

Energy technologies: The hardware that converts an energy carrier into a form of energy useful for the end-user.

Feed-in tariff: A policy mechanism designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers at fixed electricity prices.

Independent Power Producer: An entity that is not a public utility but owns facilities to generate electric power for sale to utilities and end users.

Power Purchase Agreement: A contract between two parties, one which generates electricity (the seller) and one which is looking to purchase electricity (the buyer).

Solar dryer: A device that use solar energy to dry substances, especially food. Direct solar dryers expose the substance to be dehydrated to direct sunlight; indirect solar dryers heat a black surface and the substance to be dehydrated is heated by incoming air over the surface.

Solar lantern: A lantern that uses light-emitting diodes and runs on electricity generated by solar photovoltaic panels.

Solar pump: A pump that runs on electricity generated by solar photovoltaic panels as opposed to grid electricity or diesel fuel.

Universal energy access: Reliable and affordable access by households to clean cooking facilities, a connection to electricity, and an increasing level of electricity consumption over time to reach the regional average.

List of Acronyms

AfDB	African Development Bank
BBL/day	Blue barrels of crude oil per day
COVID-19	Corona Virus Disease in year 2019
CSP	Concentrating solar power
DNI	Direct Normal Irradiance
ERA	Electricity Regulatory Authority
ESCWA	Economic and Social Commission for Western Asia
ESMAP	Energy Sector Management Assistance Program (World Bank)
FiT	Feed-in-tariff
GCF	Green Climate Fund
GEF	Global Environment Facility
GFW	Global Fund for Women
GHI	Global Horizontal Irradiance
GW	Gigawatts (billion watts)
GWh	Gigawatt-hours (billion watt-hours)
IEA	International Energy Agency
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kWh	Kilowatt-hours (thousand watt-hours)
LED	Light-emitting diode
LPG	Liquified petroleum gas
m/s	Meters per second
MDEC	Merowe Dam Electricity Company
MED	Ministry of Electricity and Dams
MFEPASA	Ministry of Finance and Economic Planning Assessment
MFNE	Ministry of Finance and National Economy
MoWIE	Ministry of Water, Irrigation and Electricity
MPI	Multidimensional Poverty Index
MW	Megawatt (million watts)
NEC	National Electricity Company
NEEAP	National Energy Efficiency Action plan
NOAA	National oceanic and atmospheric administration (US)
PJ	Petajoule (10 ¹⁵ joules)
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PV	Photovoltaic
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
REEEP	Renewable Energy and Energy Efficiency Partnership
ROR	Run-of-river (hydro)
SDG	Sustainable Development Goal
SE4ALL	Sustainable energy for all
SEDC	Sudanese Electricity Distribution Company
SETCO	Sudanese Electricity Transmission Company
SHGC	Sudanese Hydro Generation Company
STPC	Sudanese Thermal Power Generation Company
TWh	Terawatt-hours (10 ¹² watt-hours)
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Fund
USEIA	United States Energy Information Administration
WB	World Bank



(1)

Introduction

This report lays out the rationale and context underlying a national strategic roadmap of policies and measures to promote renewable energy for sustainable development and poverty reduction in Sudan. It comes at a poignant moment in the country's history, coinciding with the beginning of a Decade of Action towards the Sustainable Development Goals, the development/implementation of Nationally Determined Contributions under the Paris Climate Agreement, and a global COVID-19 pandemic that is threatening to leave deep social, economic and political impacts for years to come, particularly in a country like Sudan that is already burdened by deep poverty and chronic conflict. The roadmap seeks to seize the moment in advancing the strategic opportunities renewable energy offers to address Sudan's development challenges, including the ongoing global pandemic.

The strong linkages between energy, poverty, and gender is the point of departure for this study and national roadmap. Unequal access to energy and low human development is highly correlated (Karekezi, et al, 2012; World Bank, 2018). The lack of access to energy services restricts human capabilities to meet their needs and realize their full potential and as such it is both a cause and outcome of poverty (Practical Action, 2010). As a cause of poverty, the lack of access to energy means that opportunities for productive activities including income generation are severely limited for poor households; as an outcome of poverty, the lack of access to energy means that poor households are unable to afford goods and services that others enjoy or contribute to general social economic activities of the country. These linkages are clearly in evidence for Sudanese households.

Moreover, the relationships between energy and poverty have distinct gender overtones (Clancy et al, 2003; Fatona et al, 2013). Poor women, many in female-headed households, spend much more time than their male counterparts on energy-related activities such as firewood gathering, water fetching, and cooking. The opportunity cost of these activities prevents women from undertaking income-generating activities, which deprives poor families of much-needed income. Increased access to energy can not only reduce the burdensome workloads that women routinely bear but provide income earning potential and improvements to women's health and livelihoods. In Sudan, smoke-related illnesses associated with cooking with woodfuel are prevalent among women (MFEP, 2019).

The nexus between energy access, poverty, and gender has important implications for designing sustainable and affordable energy pathways for Sudan. It represents a necessary point of departure for understanding Sudan's sustainable energy policy choices and the ways they interact with the overall goal for sustainable development and specific goals associated with reducing poverty and promoting gender equality, especially in rural areas. A nexus approach to envisioning sustainable and affordable energy pathways seeks to account for the dynamism and potential inherent in Sudan's rural communities and establishes a framework for lifting people out of poverty in a way that acknowledges local capabilities, protects the natural resource base, and builds resilience against climatic shocks and natural resource-based conflicts.

Energy access as a poverty issue

Energy is one of the most essential inputs for sustaining people's livelihoods (Barnes, et al, 2004; Fatona, et al, 2013; Pueyo and Maestre, 2019). It is necessary to meet basic needs: to grow and cook food, to light homes, to power machines, and to enable mobility. Access to modern forms of energy has been widely recognized as an essential prerequisite for overcoming poverty, promoting economic growth, expanding employment opportunities, supporting the provision of social services, and promoting human development in general (Karekezi, et al, 2012; IEA, 2010; Pirlogeaa, 2012). Substantial reductions of poverty are impossible without greatly increasing access to affordable and reliable energy.

Access to energy is a building block of modern human progress (CDG, 2016). The availability of and access to modern energy services have been major factors in the transformation of nations and societies, as well as being a key driver in boosting human development. Historically, fossil fuels and electricity were dominant contributors to the industrialization of developed countries while developing and least developed countries relied predominantly on traditional forms of energy such as woodfuel, with slow and uneven progress toward improving access to modern and affordable energy forms. Today, only 38% of the rural population in least developed countries has access to electricity, compared to the world average of 79% (UNDP, 2019).

Access to modern, sustainable, and affordable forms of energy is a key requirement for all sectors of an economy and is necessary to provide education, health care, and other essential public services. While there is no universally-adopted definition of what "energy access" means, most definitions are aligned with household access to i) a minimum level of electricity; ii) safer and more sustainable cooking and heating; iii) modern energy that enables productive economic activity; and iv) modern energy for public services (Culver, 2017; IEA, 2019). All of these elements are crucial to economic and social development, as are other important dimensions of energy access including technical availability, adequacy, reliability, convenience, safety and affordability. In their absence, human health is impacted, economic opportunity is constrained, and socioeconomic inequality is aggravated, especially in rural areas of developing countries.

Limited access to modern and affordable energy services continues to be an important contributor to persistent poverty levels in developing countries (Karekezi, et al, 2012). Not having reliable access to modern and affordable energy forms often means spending a lot of time effort, and scarce monetary resources on securing energy supplies for basic households needs. This sets in motion a worsening cycle in which the lack of energy access leads to diminished prospects for income-earning capability, which leads to reduced purchasing power, which further limits the access to the very energy sources that could help to alleviate household poverty. This is further aggravated by the fact that poor households in developing countries spend a much greater share of their household income on energy because their incomes are so much lower and the fuels and equipment they use are so much less efficient than modern fuels and equipment.

Poverty is particularly acute in rural areas in developing countries where an overwhelming proportion of the population lives (Suttie, 2019). As of 2017, about 15% of the population in developing countries were vulnerable to multidimensional poverty, with 14.2% of the population living on less than \$1.90 in purchasing power parity (PPP) per day (UNDP, 2019). Poverty is growing in absolute numbers if not as a percentage. Notably, "energy poverty" - defined as the absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe and environmentally benign energy services to support economic and human development - is ubiquitous among these vulnerable populations and interacts with other manifestations of poverty such as poor health care, illiteracy rates, and low standards of living (Fatona, et al, 2013).

If energy poverty is to be addressed in Sudan, several changes will be necessary. It will involve transformation of the energy sector, including changes on the energy supply-side. Specifically, this will involve the set up effective enabling conditions to promote the widespread diffusion of modern, sustainable, and affordable energy technologies. This includes building institutional, financial, human and technical capacity in public sector, private sector, and civil society organizations. It entails developing an energy data infrastructure, designing effective planning systems, deployment of sustainable energy technologies, and promoting an enabling environment for investments in sustainable energy technologies. It also requires changes on the energy demand-side that focus on using energy more efficiently and in increasing the availability of affordable energy options that can reduce the drudgery of much of rural women's and girl's labor, and that at affordable prices.

Energy access as a gender issue

Energy access is not gender-neutral in developing countries. Inadequate access to modern energy forms affects women and men differently because of socially determined gender roles. Traditionally, women in developing countries have contributed directly to preserving and managing forests that provide fuelwood for cooking, while men have been predominantly responsible for extracting timber and non-timber forest products for commercial purposes (Aguilar et al., 2007). Women are also responsible for firewood collection and water fetching and, in the process, play an essential role in ensuring food security (Ibnouf, 2009). Moreover, with political and economic factors such as conflicts and seasonal and permanent migration of men from rural to urban areas, women have also had to take over farming responsibilities previously carried out by men, rendering energy-related activities even more onerous.

As a result, women and girls assume a higher proportion of the burden of unavailable energy services and inefficient energy use. Every day, millions of women and girls around the world spend hours walking far distances in the search for woodfuel, dung and other traditional biofuels (Clean Cooking Alliance, 2019). Cooking with these fuels often occurs in open fires or inefficient cookstoves in which family members, especially women and children, breathe in harmful smoke leading to health (emphysema, cataracts, cancer, heart disease, etc.) and economic burdens that disproportionately impact them over their male counterparts. Moreover, women's role in household decision-making is restricted, limiting their ability to influence processes and resource allocation on many household issues including energy (Ilesamni, 2018).

Lack of modern energy also exerts economic impacts on societies which are different for rural women than those experienced by men. The opportunity cost of firewood collection and water gathering activities frequently prevents women from effectively undertaking income-generating activities, which reduces the potential to provide poor rural households with much needed income. When rural women do engage in income-generating activities they are typically performed together with regular domestic work and are generally home-based microenterprises or small projects such as sewing, weaving, and preparing food to sell (Fatona, et al, 2013). Traditional energy policies have inadequately addressed or have largely ignored that critical role women play in energy systems, particularly in rural areas.

If gender aspects of the energy access challenge in rural areas of Sudan are to be adequately addressed, at least two major transformations have to take place. Firstly, energy planning will need to systematically integrate the links between gender equality, energy, and development within government priorities and approaches. This will involve responsiveness by energy sector planning to ensure the supply of clean, affordable and reliable energy services as well as the provision of demand-side equipment that can reduce the drudgery of much of women's labor, and that at affordable prices. Second, women will need to be empowered to make choices about energy; enabling choice is not only linked to issues of sustainable livelihoods and poverty alleviation, but also to access to income generating activities. However, there is more at stake than just improvements in women's financial resources. Women should be able to act upon the energy choices open to them, and their scope for this type of action is linked to decision-making within households. Such a shift in decision-making requires women's social and political empowerment.



Energy access as a sustainability issue

Sustainable energy supplies are instrumental to economic development and the transition from subsistence economies to modern market-oriented societies. This was explicitly recognized nearly 20 years ago at the World Summit on Sustainable Development in Johannesburg. Inadequate access to energy was recognized as both a cause and effect of poverty as the following mandate was enshrined in its Plan of Implementation, to: “. . . improve access to reliable and affordable energy service for sustainable development sufficient to facilitate the achievement of the Millennium Development Goals . . . bearing in mind that access to energy facilitates the eradication of poverty” (UN, 2002).

Sustainable energy has been defined as the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs (Lemaire, 2004). Effectively, sustainable energy is power that can be fully replenished and causes no long-term damage to the environment. Sustainable energy includes two major components, namely renewable energy sources such as hydroelectricity, biomass, geothermal, wind, wave, tidal and solar energies, as well as energy efficiency. Sustainable energy stands in contrast to traditional energy supply and use based on fossil fuels such as coal, oil, and natural gas - depletable resources and hence inherently unsustainable – that when combusted produce air pollutants that can damage human health and the environment as well as greenhouse gases that contribute to climate change.

Sustainable Development Goal 7 explicitly recognizes energy access as a sustainability issue. The UN’s Sustainable Energy for All (SE4ALL) Initiative embodies this notion in its aim to improve access to affordable, reliable and sustainable energy to end extreme poverty and promote shared prosperity. SE4ALL advocates the importance of integrated approaches to universal access to energy including delivering power to the billion people around the world currently living without electricity, providing improved fuels for cooking and heating to almost 3 billion people who don’t have access, increasing renewable energy share and improving on energy efficiency. Its “Integrated Electrification Pathways” concept, for example, proposes the development of inclusive planning approaches and policy measures that can support a range of options—grid, mini-grid and off-grid technologies— for providing affordable electricity and the associated energy services necessary to meet human needs and contribute to sustainable development.

The COVID-19 pandemic has highlighted the importance of energy access in mitigating its effects on people’s livelihoods and the economy (UNDP, 2020). The ability of people to implement social-distancing measures, and first responder’s to provide effective treatments, depend to a large extent on the availability of stable energy services. In Sudan, the number of new cases has increased rapidly, from 1 in mid-March to 9,573 cases by 29 June, triggering even greater pressure on already constrained government budgets. Access to reliable and affordable energy will be a prominent feature of preparing for, responding to, and recovering from the virus.

If energy access as a sustainability issue is to be adequately addressed in Sudan, at least two key actions will be necessary. Firstly, public-private partnerships will need to be formed in order to unlock finance to achieve universal access to sustainable energy to drive further, faster action toward the achievement of SDG7. This will promote universal access to sustainable energy in the coming decade and meeting the goals of the Paris Agreement which calls for reducing greenhouse gas emissions to limit climate warming to below 2 degrees Celsius. Secondly, the full range of the evolving suite of off-grid and distributed renewable energy services should be explored to address inequalities across gender and resource conflict-plagued communities.



(2)

The Energy Context in Sudan

A good understanding of a country's energy situation is the foundation of sustainable energy planning, including fossil and renewable sources, electrification levels, and environmental impacts (Terrados, et al, 2010; Hermann, et al, 2014; IEA et al 2019a). This is especially true in the context of the poverty eradication targets of SDG-1 because the kinds of energy produced as well as the interaction between energy supply and demand will have to change in fundamental ways to realize its critical role in poverty reduction. Without a comprehensive understanding of the current energy context, inequity will likely increase, environmental damage may accelerate, and economic growth will be jeopardized. In the subsections that follow, an overview is provided of the energy situation in Sudan, covering the magnitude of its fossil and renewable energy resources, its energy supply and consumption patterns, and the progress that has been made in achieving SDG-7 target

Energy resources

Sudan is endowed with a significant amount of energy resources. Renewables resources include solar, hydro, wind, geothermal, and biomass energy physical resources. Fossil resources include reserves of oil and natural gas. At present, except for large hydro and biomass, renewable resources remain largely untapped. A brief overview of energy resources and the technologies available to exploit them is provided in the subsections that follow.

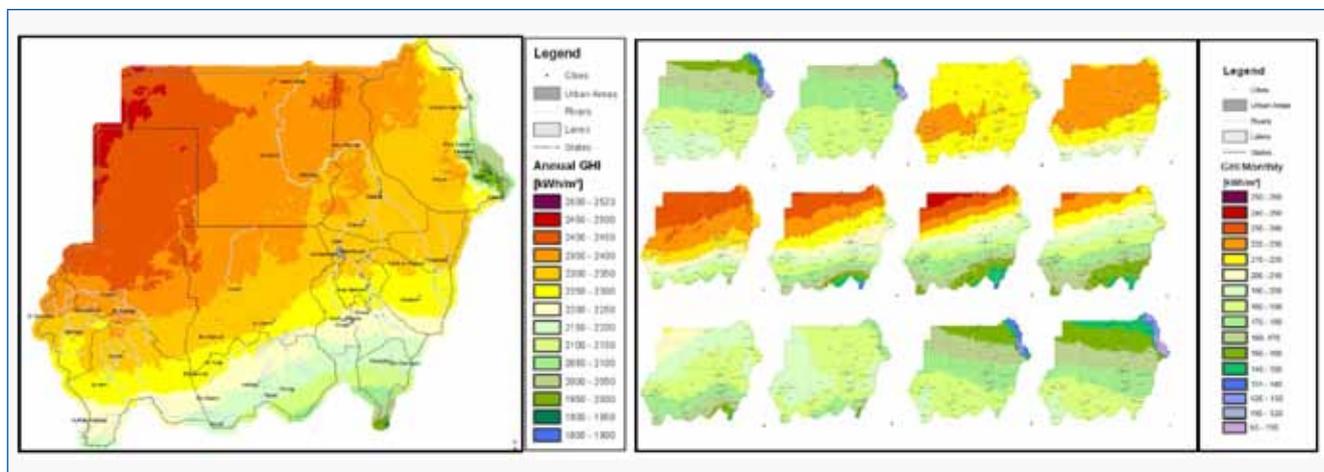
Solar: The solar energy resource potential of Sudan is very high throughout the year and across the entire country (El Zein, 2017; Omer, 2015). Sudan is one of the 148 Sunbelt countries located close to the equator where the metrics used to quantify solar energy potential are very high for electricity generation via by photovoltaic (PV) or concentrating solar power (CSP) systems. Key measures of the country' solar resource potential are briefly outlined in the bullets below.

- **Global Horizontal Irradiance (GHI):** This is the total amount of shortwave radiation received from above by a surface horizontal to the ground. It consists of both Direct Normal Irradiance and Diffuse Horizontal Irradiance (see Box 2-1). GHI values are of particular relevance for assessing the effectiveness of solar PV installations. In 2011, Sudan's Ministry of Electricity and Dams (MED), recruited Lahmeyer International GmbH to develop a country-wide solar atlas for GHI which shows values between 2,000 and 2,500 kWh/m² indicating very good solar potential for the use of PV technology (see Figure 2-1, left).
- **Direct Normal Irradiance (DNI):** This is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky. DNI values are of particular relevance for CSP technologies. While a DNI assessment was not undertaken by Lahmeyer International GmbH, a Global Solar Atlas was developed by the World Bank Group to support the scale-up of solar power around the world. It provides high-resolution estimates of DNI for Sudan (as well as other solar irradiance metrics) that show levels well in excess of 1,800 kWh/m² for large portions of Sudan, the minimum level of DNI needed for cost-effective CSP projects (see Figure 2-1, right).

Box 2-1: Measures of solar resource potential for PV and CSP technologies

- Direct Normal Irradiance (DNI): the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky. DNI is the component of solar radiation that directly reaches the surface.
- Diffuse Horizontal Irradiance (DHI): the amount of radiation received per unit area by a surface that does not arrive on a direct path from the sun, but has been scattered by molecules and particles in the atmosphere. Basically, it is the illumination that comes from clouds and the blue sky.
- Global Horizontal Irradiance (GHI): the total amount of shortwave radiation received from above by a surface horizontal to the ground. This value is of particular interest to photovoltaic installations and includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DIF).

Figure 2-1: Solar irradiance in Sudan. Left: Average Annual GHI distribution (UN Sudan Information Management Working Group, Solar data: Geomodel). Right: Average Monthly Global Horizontal Irradiation



Estimates of DNI for Sudan (as well as other solar irradiance metrics) that show levels well in excess of 1,800 kWh/m² for large portions of Sudan, the minimum level of DNI needed for cost-effective CSP projects.

Currently, the major uses of solar energy in Sudan is for electricity generation in areas not connected to the central electric transmission grid and for irrigation pumping (Omer, 2001; Ali, 2018; Elzubeir, 2018). Solar PV systems absorb and convert sunlight directly to direct current electricity. They can be either off grid (e.g., rooftop PV) with energy stored in a battery and the stored energy accessed by use of an inverter which converts the stored energy to alternating current for use in residential and commercial appliances (e.g., lighting) or in the agricultural sector for irrigation purposes (see Box 2-2). Solar PV systems have become a cost-effective source of electricity in Sudan, especially in regions where solar energy potential and grid extension costs are high.

Concentrated solar power systems are also potential options for Sudan. These systems generate electricity when concentrated light is converted to heat which drives a steam turbine connected to an electrical power generator. There are several types of systems available, including parabolic troughs, solar towers, stirling dishes, among others. While costs have come down over the past decade, they are still higher than most fossil alternatives and are limited to areas with very high solar energy potential. In 2010, an agreement was reached between Sudan's Ministry of Energy and Mines and Solar Euromed, a French CSP developer, for the development, construction, and operation of a 2 GW Solar Power Plants Program to be implemented over the coming decade.

Hydro: The major potential uses of hydro energy in Sudan are for electricity generation, mechanical power, and irrigation. Hydropower is derived from the energy of falling or fast-running water that is channeled through a turbine to produce electricity. Hydropower systems for tapping resource potential are differentiated by the electric capacity of the station as well as either "run-of-river" (ROR) or reservoir-based systems. Hydro resources can also be used for the production of mechanical energy to power machinery, with no electricity produced. The most common technology is associated with water mills, structures that uses a water wheel or water turbine to drive a mechanical process.

Box 2-2: Solar PV technology and irrigation in Sudan (Takouleu, 2020)

UNDP and Global Environment Facility invested US\$5 million for 1,469 solar water pumps in Northern Sudan in 2016. Based on the success cases, the UNDP and KOICA invested additional US\$7 million for 450 solar water pumps at River Nile State in 2020. Sudan recently received a grant from the African Development Bank (AfDB) to install nearly 1,200 solar pumps for irrigation on farms in the states of West Kordofan and North Kordofan, based in part on the success of the solar pumping earlier interventions. The grant of US\$ 21.7 million will help boost the productivity of plantations while facilitating the process of phasing out the use of diesel pumps. This will benefit farmers who will no longer need to buy diesel to run pumps, which is traditionally scarce and relatively expensive in rural areas. About 75% of the cost of installing solar pumps on the plantations will be borne by the government, with the remaining 25% payable in installments over three years.

The large-sized hydro resource potential of Sudan has been significantly exploited for electricity generation (International rivers, 2015). Large-scale hydropower is a largely cost-effective electricity source in Sudan, offering good efficiency, operational flexibility and low operating and generation costs. The large-hydro physical potential in Sudan (i.e., greater than 100 MW and reservoir-based) is estimated at about 4,860 MW, with about 2,200 MW technically feasible through 2030 (Lahmeyer International, 2012; UNEP, 2017). Of this potential, Sudan's installed hydro capacity was 1,928 MW as of 2017 and consisted of six large reservoir dams (IRENA, 2019). However, large hydropower projects pose serious impacts on water availability, ecosystems and the environment. Future large hydro development will therefore need to address public acceptance and environmental protection issues, along with high initial investment costs and long payback periods, long approval and construction cycles, and long lead times to obtain or renew concession rights and grid connections

On the other hand, the potential of pico- through medium-sized ROR systems is also potentially large. While the physical and technical potential of ROR systems in Sudan has not been assessed, such systems offer advantages in terms of better prospects of public acceptance and much smaller environmental footprint issues. There are many potential locations in Sudan for mini-sized hydro stations (e.g., Jabal Marra streams) as well as for small-sized hydro stations (e.g., Jazeera, Managil and Rahad canals) that could be the basis for off-grid electric systems to meet rural electricity demand.

Wind: The major potential uses of wind energy in Sudan are for electricity generation and mechanical power. Wind turbine technology for electricity generation consists of the turbine itself which can be oriented along either the vertical or the horizontal axis. Turbines can be located onshore or offshore and be connected to the central grid or serve a captive load as stand-alone installation. Overall generation efficiency is typically 30-40% at wind power facilities, with about half of energy losses occurring at the blade and rotor, followed by smaller losses at the gear-house and generator. In contrast, windmill technology for mechanical power converts the kinetic energy in the wind for direct use in specific tasks such as pumping water or grist milling, without the production of electricity.

Wind resources can vary significantly over an area of just a few kilometers because of local terrain influences on the wind flow. In Sudan, the highest average wind speeds globally are generally found in the areas in proximity to the Red Sea as well as on ridgelines/plains in the central and northern parts of the country. At a height of 50 meters, the EMD International calculation shows there is a substantial wind resource in Sudan that could be tapped to generate electricity (EMD, 2019). This is illustrated in Figure 2-2 and summarized in the bullets below. Box 2-3 provides an overview of recent project efforts to harness wind power in the northern part of Sudan where wind regimes are significant.

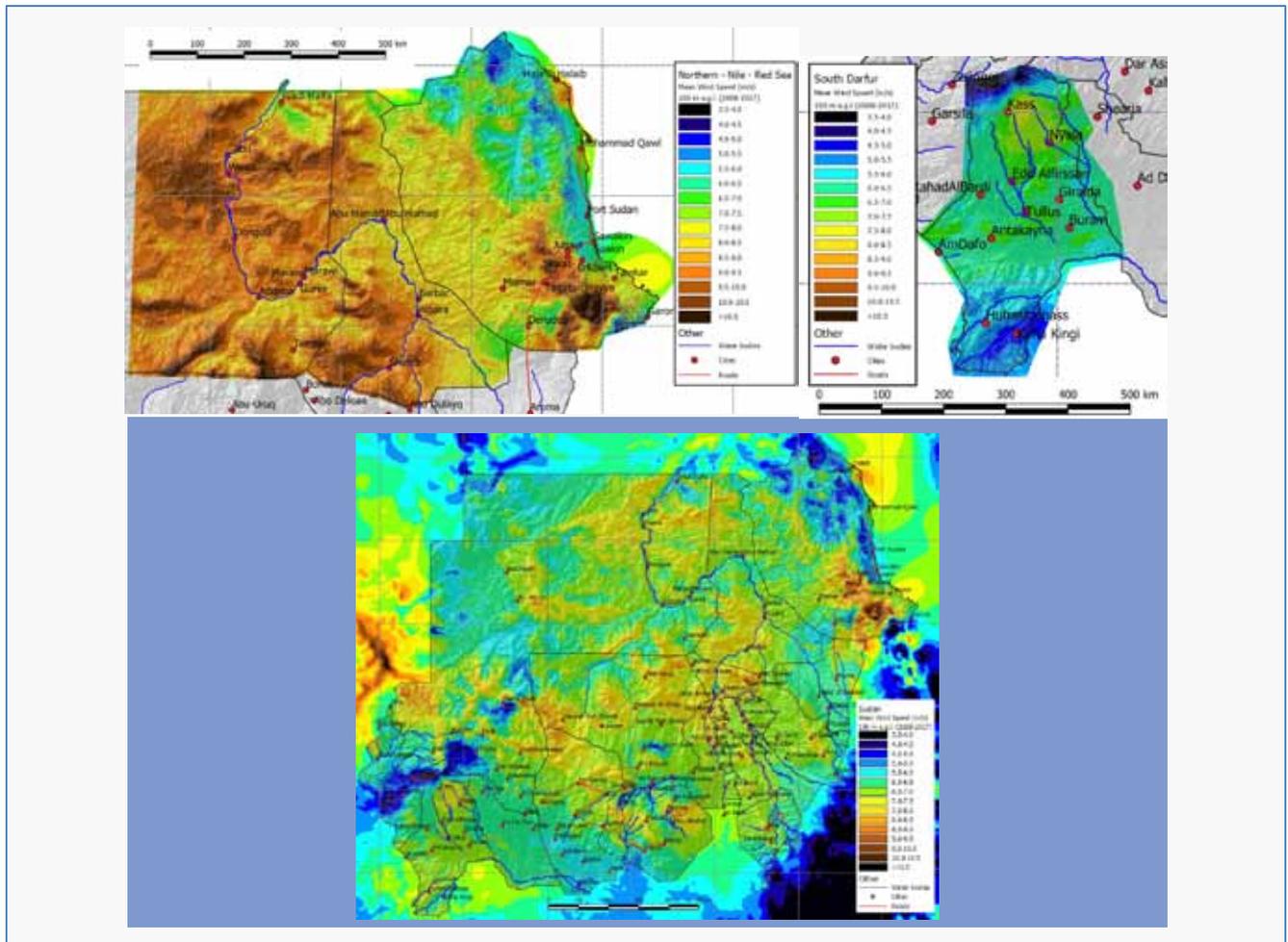
- *Wind power density distribution:* The spatial distribution of wind power density in Sudan is illustrated, which shows that the areas with the highest wind power density are located in the northern part of the country, with the highest densities in the vicinity of the Red Sea.
- *Mean wind power density range:* The average wind power density in Sudan ranges from about 250 to 664 W/m². The top 10% of land in the region has an average wind power density of 500 W/m² which is at the lower bound of Wind Power Class 5, signifying good potential.
- *Mean wind speed:* The average wind speed in Sudan ranges from about 6.2 to 8.9 meters per second. The top 10% of land in the region has an average wind speed of 8.14 m/s at a height of 50 meters.
- *Wind roses:* The wind roses for frequency, speed and power indicate a predominance of winds from the northeast of the region.
- *Roughness length:* This corresponds to the roughness length of the terrain which has a major impact on the wind resource. Much of the north of Sudan where wind speeds are greatest show very low roughness length, from 0 to 0.001 meters.
- *Orography:* This corresponds to the elevation variation over the terrain which also has a major impact on the wind resource (e.g., winds accelerate near the crest of hills and ridges). Much of the region shows the mid orography range, from 200 to 500 meters.

- *Ruggedness index*: This corresponds to the steepness or ruggedness of the terrain which adversely affects wind speed and power density. Much of the region shows less than a 15% ruggedness index.

Box 2-3: Wind power development in Sudan (UNDP/GEF, 2014)

In a project implemented by the UNDP, the GoS committed US\$ 213.3 million together with a US\$ 3.5 million grant from the Global Environment Facility (GEF) to introduce utility-scale wind power in Sudan. The objective of the project is to install a 100 MW windfarm in Dongola in Northern State. A phased implementation approach has been adopted the wind farm, with 5 MW to be built in 2014, 20 MW in 2015, and 25 MW to be built in each year between 2016-2018, to reach the 100 MW total. The project also aimed to put in place legislation and a framework to promote private sector involvement in renewable energy in Sudan. The intended outcome of the project is the development of standardized guidelines and procedures for future wind farms to facilitate future GoS efforts to tender wind farms as IPP projects.

Figure 2-2: WIND ENERGY RESOURCES FOR THE REPUBLIC OF SUDAN (EMD, 2019)



Biomass: Unlike the renewable energy resources discussed above, the use of biomass energy in Sudan is largely associated with providing heat for cooking (Omer, 2005; Omer, 2018). In rural areas of Sudan, most households do not have access to clean cooking fuels or technology and are reliant on inefficient cookstoves to burn biomass in the form of firewood, charcoal, and agricultural residues. In the case of firewood and charcoal, this has led to environmental degradation as supplies of dead firewood are used up and communities rely on cutting down live trees in an unsustainable manner.

Nevertheless, biomass in the form of firewood, charcoal, agricultural residues, bagasse and bioethanol is consumed by almost all economic sectors. While firewood is the predominant fuel in the residential sector in rural areas, charcoal is used in the commercial and service sectors, and small amounts of bagasse are even used a fuel for power/heat cogeneration (Rabah, et al, 2016). While its share of total energy supply has been declining, biomass energy accounts for the largest share in Sudan’s energy mix, estimated at 56% of total energy supply in 2014.

Despite its prominent role in Sudan's energy mix, the biomass resource potential has not been quantified, likely due to the fact that biomass is not projected to play a future role in electricity generation in Sudan except for small amount used in cogeneration plants.

Geothermal: There is about 400 MW of potential geothermal energy in Sudan (REEEP, 2012). Geothermal potential is located in different regions around the country. For instance, in the Darfur region the Jabel Marra volcano and the Tagbo and Beidob hills have registered good measurements, while further north towards the Red Sea there is geothermal activity near the Bayud volcano. Although there is currently no electricity from geothermal sources, the government is looking to neighboring Kenya which has much experience in exploiting geothermal energy for guidance in this area (REEEP, 2012).

Fossil fuel resources - oil and gas: Sudan has significant amounts of proven oil reserves. Prior to the separation from South Sudan in 2011, Sudan had proven oil reserves of 5 billion barrels of crude oil including lease condensate reserves (USEIA, 2019). Due to the separation, the ownership and control of about 75% of its oil reserves were transferred to South Sudan. The result has been a decrease in oil and other liquids production from 455,000 BBL/day in 2011 to 95,000 BBL/day in 2012 - the year after separation - to 82,000 BBL/day in 2019 (USEIA, 2019). While the lifting of US economic and trade sanctions on 13 January 2017 has been a positive development regarding the potential for foreign investment, there is as yet little progress toward developing new oil fields (USEIA, 2019).

In addition, Sudan has proven natural gas reserves of 3 trillion cubic meters as of January 2019 (USEIA, 2019). Despite these proved reserves - roughly double those of Kuwait and on par with those of Iraq - Sudan does not produce natural gas either for commercial use or for domestic consumption. All of it is either flared during oil extraction operations - about 383 million cubic feet in 2017 (NOAA, 2019) - or re-injected into associated oil fields. Regarding other resources, Sudan does not possess other fossil fuels such as coal, oil shales, or tar sands.



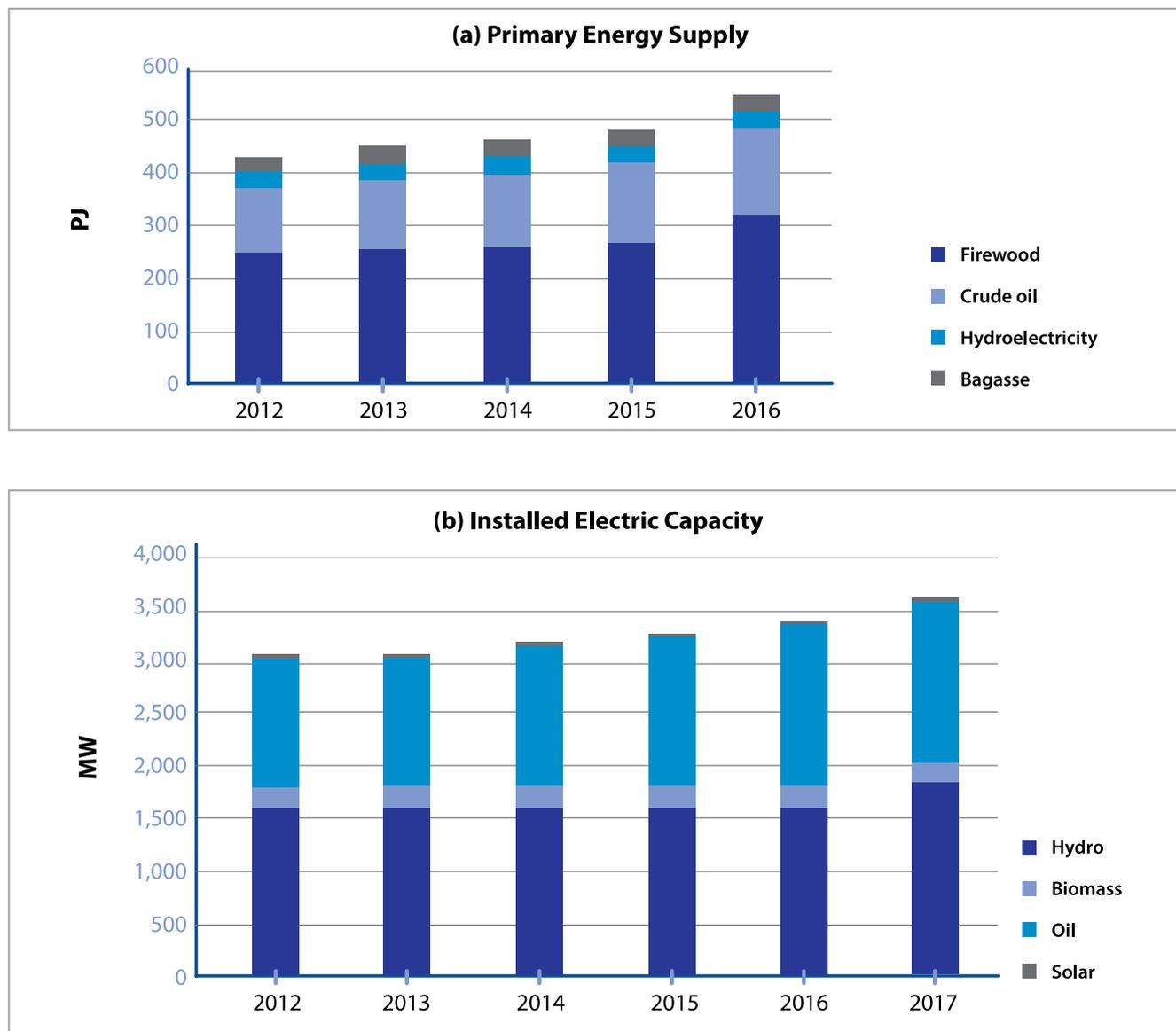
Energy supply patterns

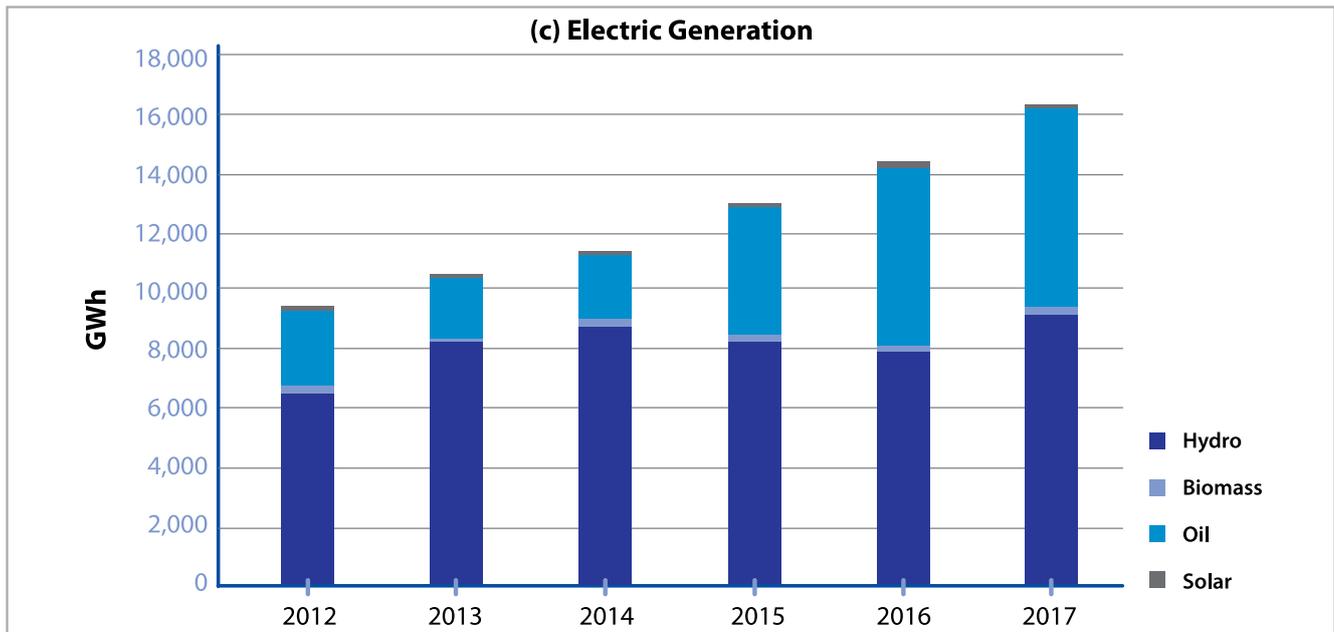
There are currently three major forms of primary energy supply in Sudan, namely biomass, oil, and hydro. Over the period 2012-2016, primary energy supply has grown from 428 PJ to 548 PJ, an average annual growth rate of about 6.3% per year (see Figure 2-3a). Biomass in the form of firewood consistently accounts for the largest share of primary energy supply in Sudan, almost 60%, followed by oil (between a 29% and 32% share) which has showing the highest rate of growth, roughly 8.4% per year. Biomass in the form of bagasse (between a 5% and 8% share) and hydro (between a 5% and 7% share) round out primary energy supply.

Installed electric generating capacity is comprised of renewable and thermal facilities. Over the period 2012-2017, total installed electricity capacity in Sudan has increased from 3.05 GW to 3.59 GW, an average annual growth rate of 3.3% per year (see Figure 2-3b). Renewable capacity is mostly made up of large hydro-based stations which account for around half of all installed capacity. Biomass in the form of bagasse is consumed in cogeneration units at industrial facilities and accounts for less than 10% of installed capacity. Solar PV capacity, while small, has been increasing steadily, roughly 7% per year. The remaining electric generating capacity consists of oil-fired thermal units which account for just under half of all installed capacity and has been growing at about 4.4% per year.

Power production has been growing rapidly in Sudan. Over the period 2012-2017, electricity generation in Sudan has increased from 9.52 TWh to 16.43 TWh, an average annual growth rate of 11.6% per year (see Figure 2-3c). The large Merowe (1,250 MW) Rosaires (280MW) and other smaller hydroelectric plants account for the largest share of power production, although its share has been decreasing by around 4% per year. Electric generation from oil-fired thermal units has shown strong growth, about 20% per year, and experienced an increase in share from 29% to 42%. Bagasse-fired cogenerated electricity and solar PV-generated electricity account for under 2% of total annual electricity generation, although solar generation has been growing at a rate of nearly 30% per year.

Figure 2-3: Energy supply patterns in Sudan, 2012-2016 (Balachandra, 2019)





Electricity transmission in Sudan is based on two main systems, grid-connected and off-grid. The national grid-connected system supplies mainly central, eastern, northern, southern Sudan and parts of western Sudan. Two of these grids - the Blue Nile and Western grids – are interconnected though they cover only a small portion of the country. Transmission and distribution losses are about 5% and 19% respectively (World Bank, 2016). Off-grid systems rely largely on diesel fuel and are essentially isolated small-scale thermal power plants that supply remote cities or regions.

Energy consumption patterns

Sudan’s energy consumption patterns have experienced strong growth in recent years, especially for certain fuels.

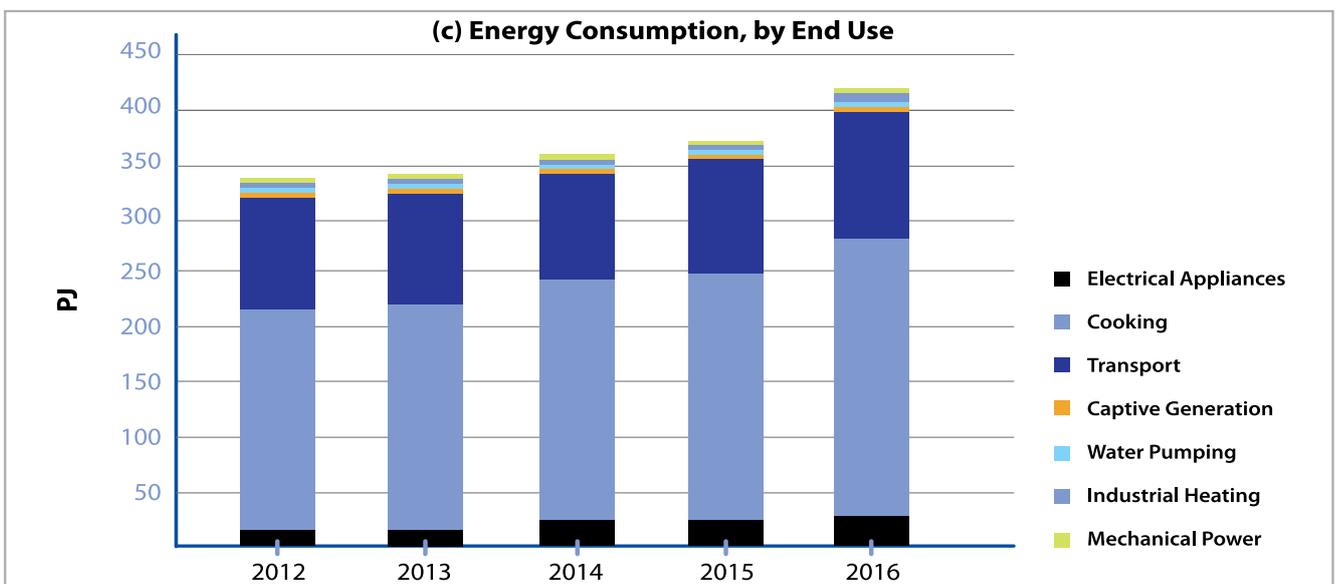
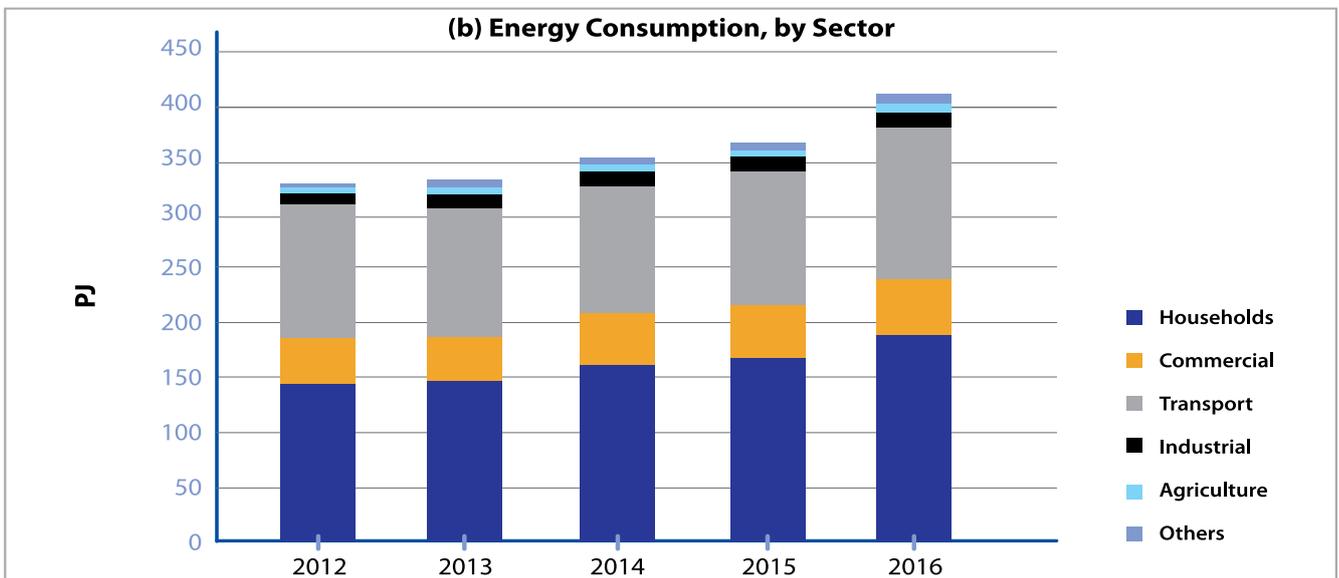
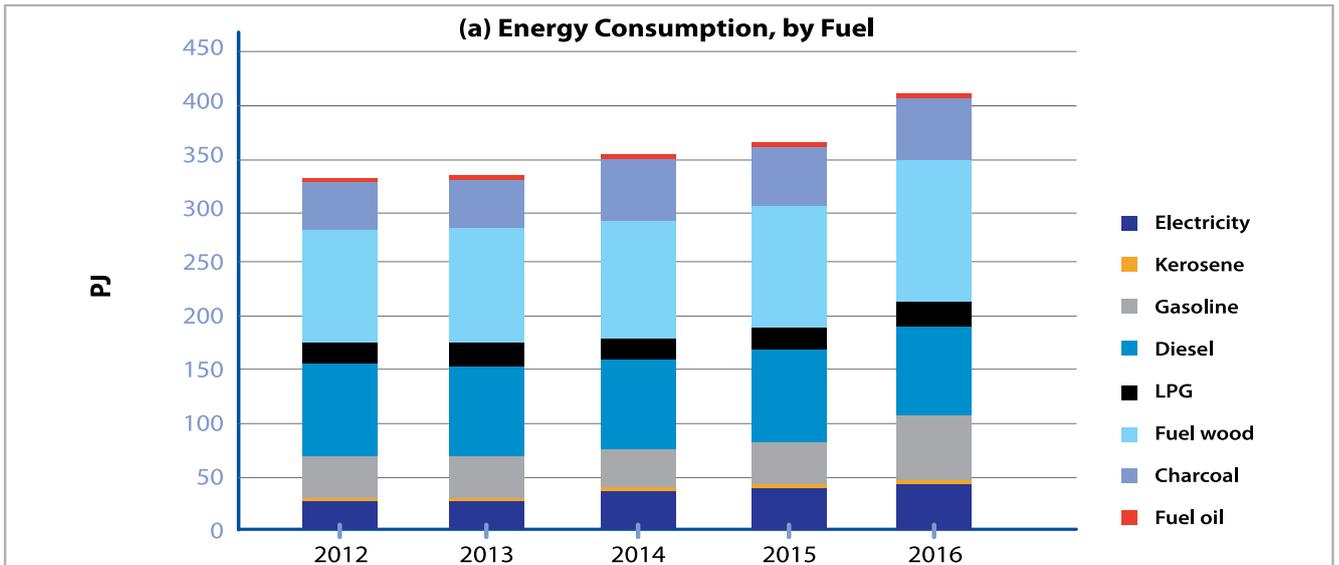
Between electricity (a secondary energy source) and the seven types of primary fuels (kerosene, gasoline, diesel, LPG, fuelwood, charcoal, and fuel oil), energy use has increased from 358 PJ to 434 PJ over the period 2012-2016, an average annual rate of about 5% per year (see Figure 2-4a). Kerosene and diesel consumption show the highest annual growth rates of 29% per year and 11% per year, respectively. Biomass (fuelwood, charcoal) annually account for between 42% and 44% of energy use and shows a growing share of total energy use. Fossil fuels annually account for roughly the same share of energy use though showing a declining share of total energy use.

The household and transport sectors dominate energy consumption in Sudan. Household energy use in the form of electricity, LPG, and biomass accounts for about 45% of all energy use and has been growing rapidly at an average annual rate of nearly 7% per year. For the transport sector, gasoline and diesel use accounts for about 34% of all energy use and has been growing more slowly at an average annual rate of about 3.3% per year. Combined, all other sectors (commercial, industrial, agricultural, others) account for only 20% although they are experiencing average annual growth of nearly 7% per year. Sectoral energy consumption patterns over the period 2012-2016 are summarized in Figure 2-4b.

Cooking/heating and car/truck end uses account for the largest shares of energy consumption. Cooking/heating with firewood, charcoal, and LPG accounts for about 60% of all energy use, and has been growing rapidly at an average annual rate of nearly 6% per year. For the cars and trucks, gasoline and diesel use accounts for about 34% of all energy use and has been growing more slowly at an average annual rate of about 3.3% per year. Combined, all other end uses (electrical appliances, water pumping, process heat, captive generation, mechanical power) account for only 11% of annual energy use although they are experiencing average annual growth of nearly 10% per year. Energy end use consumption patterns over the period 2012-2016 are summarized in Figure 2-4c.

Rapidly increasing electricity demand has posed serious planning challenges for Sudan. Over the 2012-2016 period, electricity demand has increased by about 13.2% per year. However, needed investments in generation have not kept up with this trend. Even with thermal generating more than doubling from around 2,000 GWh in 2014 to 4,600 GWh in 2015 to meet increasing electricity demand, as much as 40% of the peak demand can be subject to load-shedding in the summer months of May through August (World Bank, 2016).

Figure 2-4: Energy consumption patterns in Sudan, 2012-2016 (Balachandra, 2019)





(3)

The Poverty Context in Sudan

Sudan is one of the least developed countries in the world. As of the end of 2018, Sudan ranked 168th out of 189 countries according to the Human Development Index (UNDP, 2019). The country's poverty situation has been aggravated by prolonged years of conflict, a volatile security situation in the Darfur states, a political transition with the secession of South Sudan, an unsustainable national debt burden, international economic sanctions, and most recently, the overthrow of a political regime through peaceful protests in 2019. Many of these factors have severely constrained poverty reduction efforts and have entrenched Sudan within the “low human development” category, the lowest of the four categories that comprise the UNDP's Human Development Index (HDI). There has been negligible change in Sudan's HDI rank over the 2013-2018 period.

Sudan's Multidimensional Poverty Index (MPI) is very high. This index complements traditional monetary-based poverty measures by capturing acute deprivation associated with three key dimensions of poverty: education, health and living standards (OPHI, 2019). It is a measure from 0 to 100 of the percentage of the population that is multidimensionally poor adjusted by the intensity of the deprivations. Overall, almost 31% of Sudan's population (UNDP, 2019), or 13 million people, live under conditions of severe multidimensional poverty, a level nearly three times more than the developing country average, and over four times more the Arab States average. A low living standard is the largest dimension of severe multidimensional poverty in Sudan, accounting for nearly 50% of the contribution to poverty.

Spatial dimensions of poverty

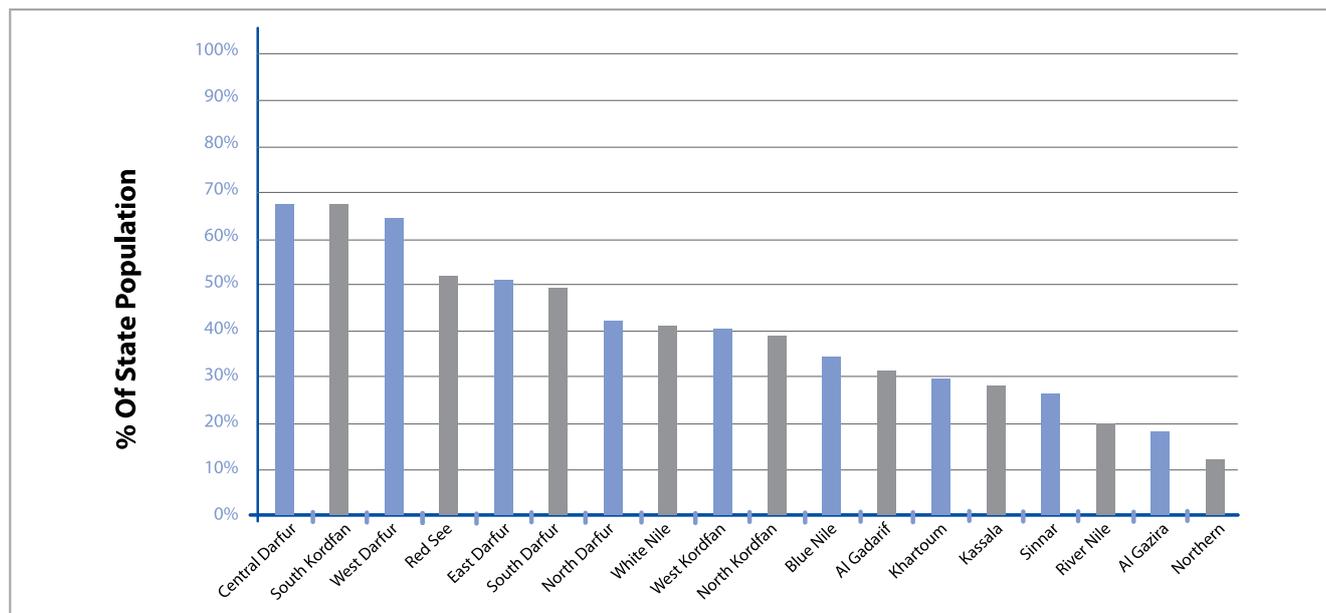
There are wide regional variations in poverty incidence across Sudan (AfDB, 2018). At the national level as of 2017, about 47% of the population (19.6 million people) lived below the national poverty line, with about 15% (6.3 million people) living on less than \$1.90 per day on a purchasing power parity (PPP) basis. About 25.7% (10.7 million people) of the population can be classified as the “working poor” living on less than \$3.20 per day on a PPP basis (UNDP, 2019). At the state level as of 2014-2015, those states with low poverty incidence - less than 20% of the state population - are the Northern, Al-Gezira, and River Nile states; the states with high poverty incidence – more than 50% of the state population - are the Red Sea and Central, South, and West Darfur states (AfDB, 2018)¹. The incidence of poverty ranges from a low of 12.2% of the state population in the Northern State to nearly 70% in Central Darfur (see Figure 3-1). Notably, Sudan's Ministry of Finance and Economic Planning estimates 65% of the population lives below the poverty line in 2020, largely due to the devaluation of the Sudanese pound which significantly reduced household purchasing power.

The incidence of extreme poverty in rural areas is significantly higher than in urban areas (ESCWA, 2017; WB/MFEPA, 2013). In 2014, rural households in Sudan were 2.5 times more likely to be acutely poor than people in urban areas.² The MPI of rural dwellers in Sudan was 0.329 compared to 0.115 for people that lived in urban areas, almost three times higher. Extreme poverty in rural areas is also reflected in measures of food insecurity, with just over 10% of the rural population unable to satisfy basic nutritional needs and suffering from severe food insecurity. In contrast, only about 6% of Sudan's urban population faces similar food insecurity conditions (ESCWA, 2017).

(1) Based on the results of the 2014-2015 National Baseline Household Budget Survey.

(2) Based on the results of Multiple Indicator Cluster Survey 2014 of Sudan by UNICEF

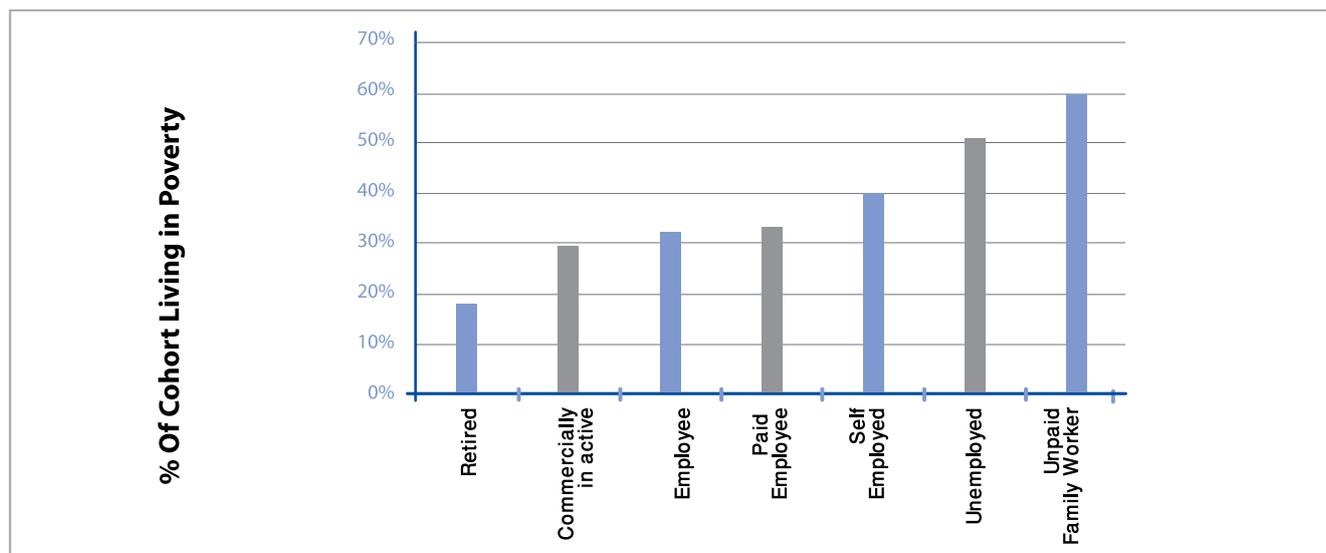
Figure 3-1: State-level poverty incidence levels in Sudan, 2014-2015 (AfDB, 2018)



Livelihood dimensions of poverty

Agriculture is the main source of livelihood for poor Sudanese households (WB/MFEPISA, 2016). On a livelihood basis, more than 60% of households in the poorest quintile rely on agriculture as their main livelihood in contrast to only 20% of households in the wealthiest quintile. On a gender basis, less than 17% of females are employed outside of the agricultural sector. However, agricultural productivity for most crops lags well behind those seen in neighboring countries and have stagnated or even declined, partly due to increasing climatic variability and recurrent droughts which adversely affect Sudan predominantly rainfed agricultural systems. Moreover, dependence on cereal imports, especially wheat, has grown considerably over the past decade, deepening food security concerns among poor households with severely constrained monetary assets. Even the livestock subsector, which generates export earnings, is facing important risks to sustainability from climate change that are exacerbating rural poverty levels.

Figure 3-2: Poverty incidence by employment category, 2014-2015 (AfDB, 2018)



Unemployment is a major cause of poverty in Sudan (AfDB, 2018). Poverty incidence stood at 51% in the middle of the last decade for the unemployed, while the level was even higher, about 60%, for unpaid family members working primarily in agricultural activities (see Figure 3-2). Currently, about 40% of the working population are considered vulnerable in Sudan, meaning they are engaged as unpaid family workers and/or self-employed workers (UNDP, 2019).

Other dimensions of poverty

Many poor households lack adequate access to basic health and other services (WB/MFEP, 2016). Many poor Sudanese households in both urban and rural areas lack adequate access to public utilities and infrastructure. Overall, access to improved water, electricity and mobile phone by the poorest 20% of the population was limited at 20% a decade ago. As of 2017, the situation had improved considerably with 43% of the rural population having access to electricity; 60% having access to clean water supply, and 37% having access to basic sanitation facilities (UNDP, 2019). Nevertheless, the overwhelming majority of rural Sudanese households rely exclusively on firewood for cooking and heating, with the poorest households spending a larger share of their income on utilities, compared to their richer and urban counterparts. The COVID-19 pandemic is likely to exacerbate this situation as many health facilities in rural Sudan lack access to energy services or suffer from unreliable energy supply, impeding health service provision.

The incidence of poverty in Sudan strongly correlates with education levels (AfDB, 2018). Poverty rates are highest for those living in households whose head has no education and are also high for those whose heads have only some primary education and those who report that preschool is their highest level of education completed. Besides direct linkages with poverty, education outcomes are closely linked with employment outcomes (see Figure 3-3). Individuals who attain higher education are significantly more less likely to be living in acute poverty than individuals who have never attended school or who have only completed pre-school level, suggesting that education is an essential dimension for reducing poverty.



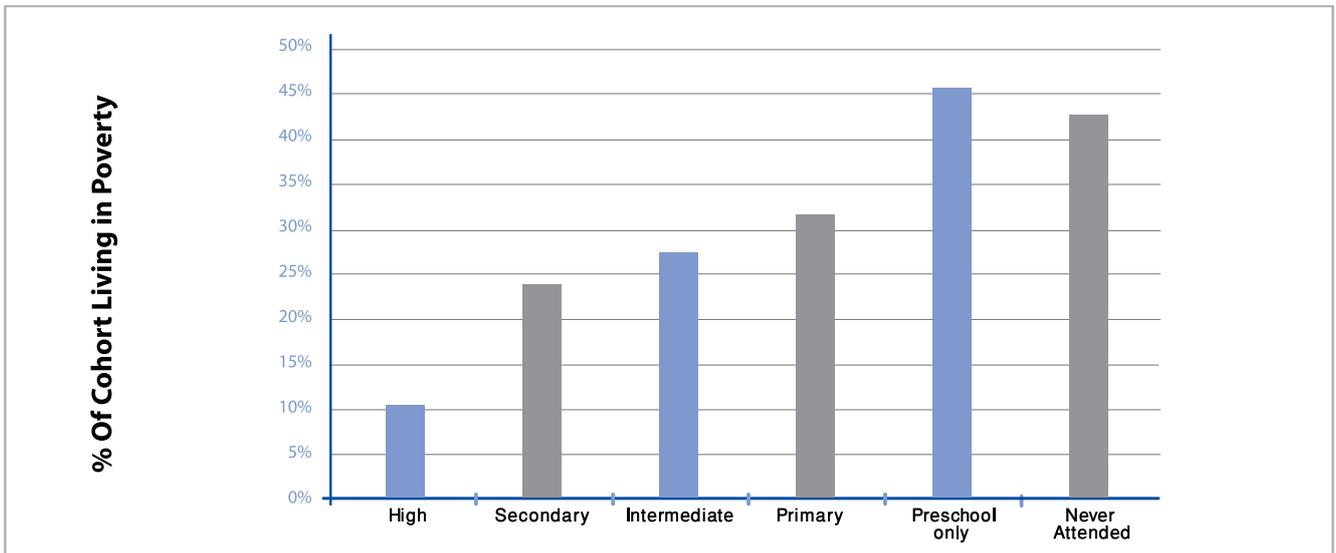


(4)

The Gender Context in Sudan

The energy-poverty nexus has distinct gender dimensions (Cecelski, 2000; Clancy and Batchelor, 2013). In Sudan, female-headed households are poorer than male-headed households, many of whom live in rural areas (Faki et al, 2011). Also, only 24.5% of women in Sudan aged 15 and older participate in the labor market compared to 70.3% for men (UNDP, 2019). These facts are important to address when considering renewable energy services for poverty reduction for two major reasons. First, men and women have different energy needs and therefore may have very different notions about sustainable livelihoods and the appropriate level of energy services. Second, women and men have different access to resources and decision-making, with women’s access to decision-making within households and communities restricted, limiting their ability to influence processes and resource allocation on many issues including energy (Clancy and Batchelor, 2013).

Figure 3-3: Poverty incidence by level of education, 2014-2015 (AfDB, 2018)



The evolution of women’s empowerment in Sudan has become evident during the recent political turmoil in Sudan. In 2019, worsening economic and other conditions sparked street protests that eventually led to the removal of the former regime. It was estimated that over 70% of demonstrators were women with many people calling it the “women’s revolution” (GFW, 2019). Though women were instrumental in the protests, they were sidelined from the initial peace talks between civil society and the military. Eventually, due to persistent pressure, the transitional government included two women on the 11-member Sovereignty Council overseeing the transition.

Four female ministers were part of the cabinet out of 15, including the first female foreign minister; and the eventual creation – as guaranteed in the constitutional charter – of the Women and Gender Equality Commission to ensure that women’s empowerment and gender equality is prioritized going forward. These recent developments suggest it is essential that gender considerations be accounted for in energy planning just they have been considered for many years in the health, water and agricultural sectors, and the time is ripe for such action.

Cross-cutting gender bottlenecks

Sudanese women are increasingly playing a stronger role in ensuring the livelihood of their families (UNICEF, 2017).

About 14% of households in Sudan are female-headed, and siblings care for younger children. These factors may lead to weaker childcare practices and increasing protection risks for children. Poor children, and mainly adolescents, are more likely to need to work and drop out of school. About 40% of Sudanese girls do not attend primary school while 42.3% of girls do not attend secondary school (UNICEF, 2017). Over one third of Sudanese women 15-49 years old are either pregnant or lactating, with a fertility rate of 5.2. They suffer early marriage, with 34% married before the age of 18, as well as the risk of sexual abuse and physical violence with 34% justifying domestic violence for various reasons (UNDP, 2019).

The main gender bottlenecks to empowerment are associated with education, restrictions in access to decision-making/services, and harmful expectations (UNICEF, 2017).

Many women have an inordinate burden of work both in terms of domestic duties and earning a livelihood for their families. There is no doubt that energy plays a major role in gender bottlenecks including meeting women’s practical and reproductive needs (such as cooking, food processing and water hauling), but it can also be seen as a component necessary to meet their productive and strategic needs (lighting to enable evening study, street lighting for safety in attending community meetings, electricity for women’s enterprise development). An overview of the major bottlenecks to women’s empowerment is summarized in Table 4-1.

Women and energy decision-making

The gender dimension of energy and poverty is prominently manifested in household decision-making (Ilesanmi, 2018).

In those households where there are adult men and women, the division of labor for energy-related activities is highly gendered. Women have the responsibility for household energy provision particularly related to fuel for cooking and water for household use. When energy has to be purchased, men control the decision-making process who decide what to buy and who owns it; for example LPG for cooking and batteries for radios. There are many examples in other settings in Africa where recreational equipment, such as TVs and radios, was bought by men before labor-saving equipment that would lessen the domestic chores borne by women. Such decision-making patterns can significantly impact total household budgets.

Table 4-1: Gender bottlenecks to empowerment in Sudan (adapted from UNICEF, 2017)

Bottlenecks	Selected examples
Lack of education and knowledge	<ul style="list-style-type: none"> Only 35.2% of mothers of unregistered children know how to register a child’s birth
Limited access to services	<ul style="list-style-type: none"> 50.1% of women have fewer than four antenatal care visits (by any provider). 5.2% of women have been tested for HIV/AIDS.
Detrimental ideals and expectations	<ul style="list-style-type: none"> In considerable number of localities, women are less valued than men.
Dual responsibilities experienced by women	<ul style="list-style-type: none"> Females have heavy work burden in terms of domestic duties and earning a livelihood for their families. Households depend on the women and girls to collect firewood and water while having other household responsibilities.
Women’s and girls’ lack of participation and decision making	<ul style="list-style-type: none"> Girls and women typically do not exercise their choices in marriage. Lack of women’s involvement in resource management (energy/water).

Women and men have different perceptions about the benefits of energy-related decisions. Typically, men see the benefits of electricity in terms of leisure, quality of life, and education for their children (Clancy and Batchelor, 2013). On the other hand, women see electricity as providing the means for reducing their workload, improving health, and reducing household expenditures. In some developing country settings, women have also been found to benefit from access to television, in which they could see pictures showing that they “don’t have to remain as second-class citizens” (Barnett, 2000).

Women and energy-related activities

In poor Sudanese households, biomass collection to meet a household's energy needs is overwhelmingly the burden of women and girls (Ali, 1994). In rural areas, this can mean spending several hours a day collecting fuelwood loads of 20 kg or more. Such gendered roles for household energy provision affects women's health disproportionately to men's (for example, higher levels of lung and eye diseases due to the longer hours of exposure to smoke and particulates in smoky kitchens experienced by women compared to men). Fuel collection also reduces the time women have available for contributing to other aspects of livelihood strategies, and girls are frequently kept away from school to assist their mothers (Clancy and Batchelor, 2013). Clearly, the burden of biomass fuel use is a major aspect of most poor women's lives in Sudan as it absorbs large amounts of time in heavy work and can have negative effects on their health.

Sudanese women employ a variety of strategies in response to the burden associated with fuelwood collection (Elzarov, 2018). These strategies include the adoption of management strategies to conserve fuel through improved cookstoves, with several notable examples of efficient cookstove diffusion in rural areas of Sudan (Malla et al., 2011). However, there are notable examples of the ineffectiveness of improved cookstove diffusion in Sudan due in large part to women's limited role in household decision-making compared to men (Muneer and Mohamed, 2003). Other strategies applied in other developing country settings include shortening cooking times, exploring less fuel-intensive cooking and food processing methods, cooking fewer meals, serving cold leftovers, changing the types of food eaten, and the purchase of other fuels (Clancy and Batchelor, 2013). Community forest management strategies have been emerging in Sudan with the implementation of recent projects as it emphasizes a sustainable supply of biomass fuels mostly for city populations.





(5)

The Energy Policy Context in Sudan

The energy policymaking context is oriented toward its two main energy sectors, oil and electricity. Biomass-related policymaking, though historically a large part of the annual energy mix, has been managed by the Ministry of Agriculture and Forests. For the purposes of establishing the policy basis for sustainable energy pathways in Sudan, the focus of this section is on electric sector policymaking undertaken by the Ministry of Water, Irrigation and Electricity (MoWIE) whose vision is to promote the efficient utilization of water and energy resources in Sudan while supporting strategic corporation with neighboring countries for sustainable development.

Legislation and institutions

There are two major pieces of legislation that provide the basis for policymaking in the electric sector of Sudan.

The Electricity Act of 2001 establishes the Electricity Regulatory Authority (ERA) as responsible for overseeing electricity generation, transmission and distribution operations in Sudan, as well as licensing and investment decisions in electric generation, transmission and distribution by Sudanese and non-Sudanese entities. The National Investment Encouragement (NIE) Act of 2013 provides a basis to encourage investment in projects in furtherance of specific goals and objectives of national strategies and development plans. Other notable developments include the Public-Private Partnership (PPP) Initiative to strengthen the policy and regulatory environment for PPPs in Sudan and proposed amendments to the Electricity Act of 2001 to encourage more private investment and effective regulation.

Several entities comprise the range of responsible actors involved in electricity planning and operational activities in Sudan. These include the Sudanese Thermal Power Generation Company (STPC), the Merowe Dam Electricity Company (MDEC), the Sudanese Hydro Generation Company (SHGC), the Sudanese Electricity Transmission Company (SETCO), and the Sudanese Electricity Distribution Company (SEDC). The emergence of these companies is a result of the 2010 restructuring of Sudan's electric sector in which the vertically integrated National Electricity Company (NEC) was unbundled into the above separate companies which took over its responsibilities for generation, transmission and distribution operations. The ERA monitors the performance of the above companies on the basis of the Electricity Act of 2001.

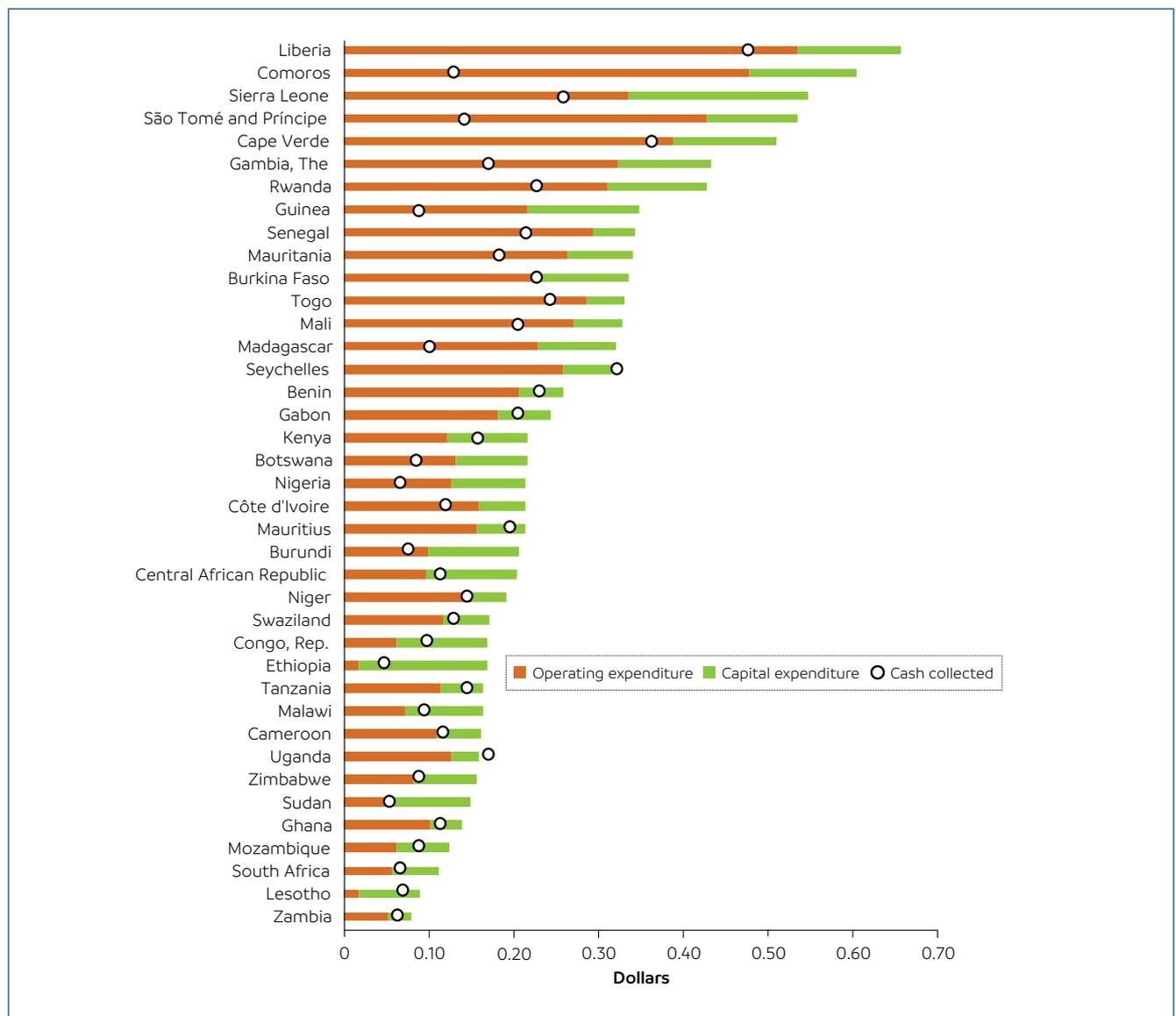
There are several major national documents that guide policymaking in the electric sector. These include The Five-Year Program for Economic Reform (2015-2019) which calls for extending the national electricity grid to all 18 states and raising the share of the population benefiting from electricity from 34% to 49% by 2019 (MFNE, 2014). The Long-Term Power System Plan (2012-2031) proposed that the least-cost option for Sudan consists of coal-based thermal generation supplemented by gas-powered generation to meet peak demand. The plan also proposes network reinforcements, including interconnection with Ethiopia and maintenance of existing hydroelectric plants. Notably, intermittent renewables such as solar and wind were not included as part of the least-cost plan (World Bank, 2019). The Electricity Sector Development Framework (2015-2020) is aligned with the long-term power system plan and further aims to reduce transmission and distribution losses to 15%.

Electricity financing and operations

The financial operation of Sudan's electric system is heavily subsidized. The retail tariff of electricity has not changed since 2004. This has led to an intensification of the level of subsidies as the revenue from customers does not cover the full cost of providing electricity service. A comparison of electric supply costs with cash collected in 2014 for African countries shows that in Sudan roughly only one-third of annual funds for delivering electricity services is provided by electric customers (see Figure 5-1). The ERA has commissioned a Cost of Service study to determine the total costs incurred in providing service to its customers and the allocation of those costs to the various customer classes, with the intent is to appropriately design electric rates then will recover these costs (including a fair return on investment) from each class.

To ensure smooth operation of the nascent private electric generation, transmission and distribution companies, funds are provided out of the national budget according to set rates for electricity generation, transmission, and distribution (World Bank, 2016a). As these set rates do not cover full administrative or operations & maintenance costs, additional funds need to be added annually on top of the agreed rates (World Bank, 2016). The government also assumes responsibility to pay the National Petroleum Corporation for the fuel costs associated with the operation of thermal power plants. Power sector creditors receive interest and principal payments directly from the government, which also assumes full responsibility for arranging finance associated with the electric sector's investment needs.

Figure 5-1: Comparison of electric supply costs with cash collected per kWh billed, 2014 (World Bank, 2016b)



Sustainable energy framework

Renewable energy policymaking is the responsibility of three overlapping entities. The General Directorate of Renewable Energy and Alternative Energy is responsible for resource assessment and planning. The aforementioned SHGC is responsible for management of Sudan's hydro resources while the SEDC oversees electricity distribution including small home systems for rural electrification and rooftop solar systems. This distribution of responsibilities has led to uncoordinated policymaking and slowed the penetration of renewable energy into the market. Capacity building, knowledge exchange and interagency staff coordination has also been suffered on account of a weak institutional planning framework.

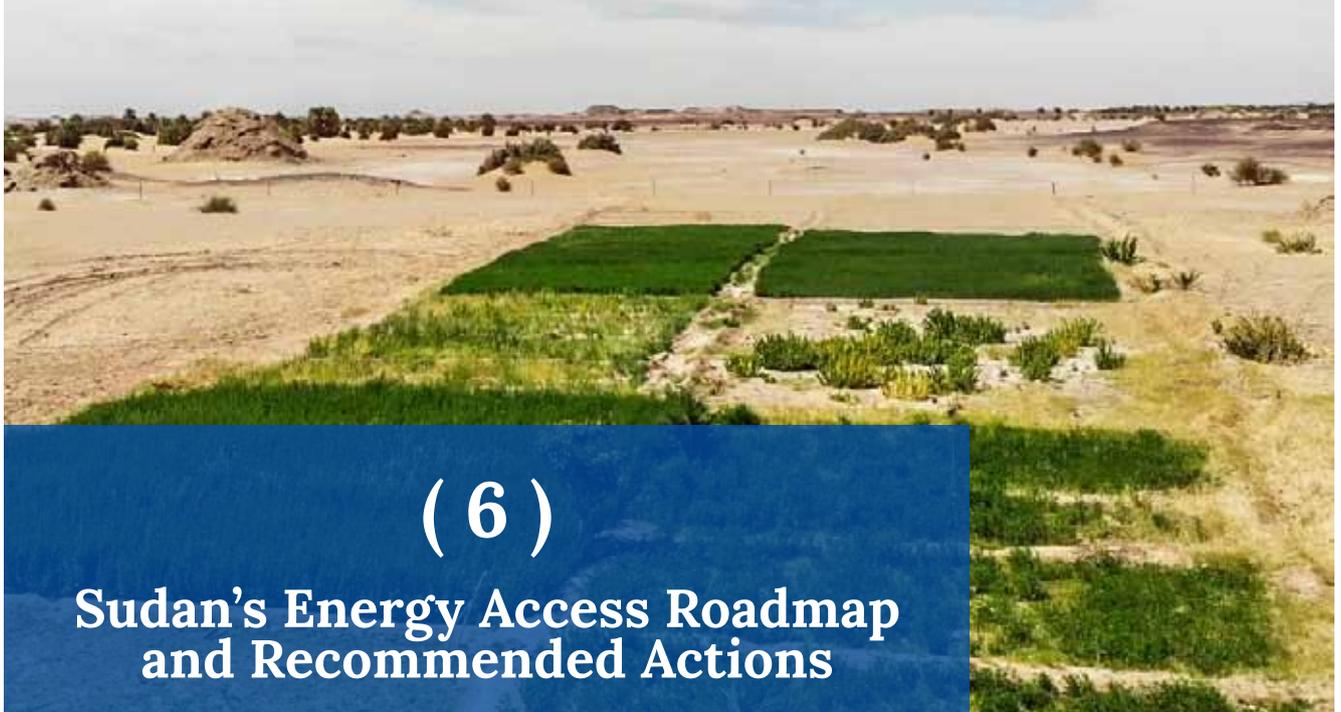
Nevertheless, there are several noteworthy renewable energy initiatives. Explorations have been underway on ways to diversify power generation beyond large-scale hydropower and thermal power. Solar and wind resource mapping exercises have been undertaken, and planning is underway for the installation of 3 wind projects totaling 300 MW and 4 solar PV projects totaling 20 MW, with feasibility studies and technical specifications completed for most of the projects (World Bank, 2016a). However, financing for all of these projects remains elusive. While not completed, a Renewable Energy Act is in process as is the Renewable Energy Master Plan to create an enabling policy environment for renewable energy investments.

Initiatives are also underway to develop demand-side-management regulations and implementation mechanisms. In 2012, the Sudanese government adopted a National Energy Efficiency Action plan (NEEAP), in collaboration with the Euro-Mediterranean Energy Market Integration Project (MED-EMIP) project of the League of Arab States, and the Regional Center for Renewable Energy and Energy Efficiency (RCREEE). The overall objective of Sudan's NEEAP is to achieve annual savings of 10% of the total energy demand starting the year 2017 to reach 12% by the year 2020. The NEEAP was reviewed and updated in October 2015. It presently contains three proposed measures to improve energy efficiency in the electricity sector – (i) Reduce electricity consumption of lighting in the residential sector and promote the use of highly efficient household appliances, (ii) Reduce electricity consumption in government buildings; and (iii) Improve the power factor in the industrial sector.

Barriers to sustainable energy

Sudan faces political, institutional and policy barriers as it seeks to promote renewable energy and energy efficiency. The current transitional government faces enormous challenges: a fragile political system; the loss of 75% of its oil revenues with the separation of South Sudan in 2011; and an economy in need of short-term stabilization and long-term structural reforms. Potential investments in renewable energy are hindered due to the delays in finalizing a new electricity law and the lack of an approved IPP Act that could enable and promote the private sector in power generation (World Bank, 2016). Moreover, policies and regulations are limited for systematically promoting energy efficiency in the residential, commercial and industrial sectors, while inadequate institutional capability remains a serious challenge.

Sudan also faces economic and financial barriers as it seeks to promote renewable energy and energy efficiency. There is rising government debt, high trade deficits and worsening foreign reserves even as average inflation rates remain very high; 63% in 2018 and 50% in 2019. For potential investors, the low electricity tariffs (US\$ 0.028/kWh for domestic customers) are unattractive for private investment in power generation while the substantial subsidies provided by the government impose significant burdens on government finances. Also, the dispersed nature of rural settlements across Sudan's large land area means that electric grid extension is very expensive while at the same time the low paying capacity by the rural customer base offers small prospects for the eventual recouping of investments. This barrier is true even for off-grid systems.



(6)

Sudan's Energy Access Roadmap and Recommended Actions

The previous sections have outlined the scope of issues and drivers underlying the development of a strategic plan to promote sustainable and affordable energy pathways in Sudan. The roadmap of recommended actions discussed in the sections that follow is focused on three key areas: i) Increase access to sustainable energy services for poverty reduction & women empowerment; ii) acceleration of structural transformation of energy sector as a means of sustainable development; and iii) energy service as key enabler for building resilience and sustainable recovery. Implementation modalities are also proposed for the short-term (within the next 6 months), medium-term (between 6 months and 3 years), and long-term (beyond 3 years).

The roadmap includes a total of 69 specific recommended actions distributed across 3 key themes and 9 strategic areas. A breakdown of the recommended actions across the key themes and strategies areas is provided in Table 6-1. Recommended actions fall into several categories, as briefly described in the bullets below and summarized in Table 6-2. The details associated with each recommended action is discussed in the subsections and paragraphs that follow.

- *Studies, plans, proposals:* Refers to actions that establish a predicate for further investments in renewable energy and energy efficiency;
- *Renewable energy and energy efficiency supporting policies:* Refers to policies to support the greater penetration of renewable energy and energy efficiency (e.g., feed-in tariffs);
- *Renewable energy pilot projects:* Refers to the introduction of a renewable energy project for demonstration purposes as an initial step toward replication and scale-up;
- *Investment strategies:* Refers to actions that promote a favorable enabling environment for private sector investment in renewable energy and energy efficient technologies;
- *Energy planning reform:* Refers to the development of new paradigm for planning in the energy sector encompassing issues such as restructuring, regulation, private sector participation, and competitive energy markets;
- *Renewable energy and energy efficiency technology diffusion:* Refers to the direct implementation of renewable energy and energy efficiency technologies at large scales;
- *Renewable energy and energy efficiency incentives:* Refers to policies, programmes, and initiatives that encourage investing in and using renewable energy and energy efficient technologies (e.g., tax credits); and
- *New business models:* Refers to new operational structures that support the viability of income-earning potential of renewable energy and energy efficiency investments.

Table 6-1: Breakdown of the 69 recommended actions in Sudan’s strategic roadmap of renewable energy policies and measures for poverty reduction

Key Themes	<i>Access to sustainable energy services for eradication of poverty in all its forms and dimensions (26)</i>	<i>Structural transformation of energy sector as a means for sustainable development (34)</i>	<i>Energy services for resilience building and sustainable recovery (9)</i>
Strategic Areas	<ul style="list-style-type: none"> Expand universal access to modern energy services for poverty eradication to all (9) Integrate and deploy decentralized energy solutions in the development of rural areas (11) Enhance energy efficiency in urban areas and strengthen capacity of increased efficient energy in the economy (6) 	<ul style="list-style-type: none"> Strengthen institutional capacity for integrating energy in evidence-based development planning (13) Initiate a process for policy de-risking of sustainable energy investments (7) Enhance capacity for disaggregated sustainable development data and knowledge management (9) Integrate renewable energy in national development planning (5) 	<ul style="list-style-type: none"> Integrate energy services in resilience building and sustainable recovery planning and programming (4) Deploy solar energy solutions for basic and productive energy services (5)

Table 6-2: Breakdown by category of recommended actions in Sudan’s roadmap for renewable energy services for poverty reduction

Type of recommended action	No.
Studies, plans, proposals	9
Renewable energy and energy efficiency supporting policies	9
Renewable energy pilot projects	3
Investment strategies	5
Energy planning reform	9
Institutional coordination and strengthening	12
Renewable energy and energy efficiency technology diffusion	14
Renewable energy and energy efficiency incentives	2
New business models	6
Total	69



Theme 1: Increase Access to Sustainable Energy Services for Poverty Reduction & Women Empowerment

The fundamental goal of the energy access roadmap is to expand access to sustainable and affordable energy in rural areas for poverty eradication and the empowerment of women. To achieve this goal, three strategic focal areas are proposed that aim to develop an enabling environment for expanding energy access; deploy decentralized renewable energy technologies; and build capacity. Combined these actions will serve to facilitate the development of inclusive productive enterprises for women, provide an effective set of policies and incentives for energy access; and lead to improved functioning of local energy markets. The specific set of actions outlined below will be critical in achieving the goal of increased energy access.

Box 6-1; Renewable pilot project example; Sudan's Solar Transformation Programme (UNDP, 2020)

The Solar Transformation Programme concept, developed in partnership with UNDP's Climate Investment Platform team, aims to scale-up financing for solar energy solutions to increase energy access in rural areas and reduce demand for heavily subsidized fossil fuels, thus contributing to:

- Increased access to and quality of health services
- Improved resilience and productivity in agriculture
- Improved livelihoods in rural areas
- Reduced pressure on public finances
- Reduced carbon emissions and air pollution

The Programme consists of four interventions, summarized in the table below, with an estimated total programme cost of USD 250 million over 5 years.

Intervention	Type of system	# of systems	Cost (USD Million)	# of beneficiaries (Million; 49.6% female; 50.4% male)
Solar for Health	Solar PV Systems	150	7.5	1.3
Solar for Agriculture	Solar Water Pumps	20,000	140	1.12
	Solar Water Yards	1,000	50	3
Solar for Households	Solar Home Systems	100,000	50	0.6
Solar for Productive Uses	Mini grids	50	2.5	0.03
Total:			250	6.05

Strategic focus 1:

Foster an enabling environment for expanded energy access

The following short-term actions are proposed:

1. Initiate and develop a detailed implementation plan for achieving universal access by 2030 (i.e., in the next 11 years). Along with this, prepare plans and programs for productive use of energy for livelihoods and income generation.
2. Evaluate rural electrification projects implemented by the Sudanese Electricity Distribution Company to identify and recommend new measures for promoting sustainable livelihoods in rural areas.
3. Prepare new pilot projects with multiplier effects and potential for paradigm shift, building on the current initiatives carried out by the Government institutions, UNDP, and other international organizations. These pilot projects may include, for example, off-grid run-of-river micro-hydro systems or decentralized renewable electricity micro-grids. Box 6-1 provides an overview of a solar pilot project example.

The following medium-term actions are proposed:

1. Focus on developing policies to attract an effective sustainable energy public and private sector investment, including for mini-grids, micro grids, stand-alone systems etc. The regulatory and policy structure should be revised, approved, and enforced to create a conducive environment for a fair and competitive market for private sector investments, which includes the creation of clear and transparent procedures to introduce new legislation and/or policy with clear revisions and timelines.
2. Encourage energy investments in the rural areas that lead to diversification of enterprises, value-added activities, livestock activities and agricultural productivity.
3. Encourage inclusivity in energy investments considering women's participation and income generation opportunities for all, including solar energy transformation initiatives such as establishment of National solar PV Fund especially to support the agricultural sector, micro enterprises and public sector in the rural areas. Ensure that no one is left behind by effective supportive policies.
4. Provide incentives that encourage innovation and private sector investments
5. Establish specialized division for universal energy access within the energy planning and/or monitoring and evaluation department should be focusing on energy access planning, monitoring and evaluation, as it is clear from the different reports about the conflicting numbers of energy access rates, with simple parameter which should be changed by multi-tier energy access parameter showing to which degree and quality energy access rates.

The following long-term action is proposed:

1. Support implementation of policies that encourage development and implementation of a wide range of energy solutions for electricity access and clean cooking.

Strategic focus 2:

Integrate and deploy decentralized energy solutions in the development of rural areas

The following short-term actions are proposed:

1. Build on UNDP interventions on solar for agriculture and food, to examine impact on poor and need for capacity building to increase agriculture productivity and value-added activities to improve return on investment from introduction solar pumps
2. Deploy mini-grids including off-the-shelf decentralized (off-grid) energy solutions like solar lanterns, solar home systems for emergency lighting and mobile charging.
3. Starting with the institutional setup, restructure directorates and departments within the Ministry of Energy and Mining relevant to the Renewable Energy Master Plan to ensure harmony between strategic planning, projects and programs preparation, projects execution, and monitoring and evaluation.
4. Draft Renewable Energy interventions aligned with NDC commitments and proposals to access climate change funds such as GEF and Green Climate Fund (GCF) with special focus on enhancing the creation of productive use opportunities (value-added products and services); promoting income generation for rural population and poor communities during the project life cycle; building climate resilience; and mitigating greenhouse gas emissions.
5. Recognize animal manure as a potent biomass resource for energy generation (biogas).

The following medium-term actions are proposed:

1. Support policy development outcomes that encourage efforts to use renewable energy to add value to resources
2. Use sustainable energy technologies and solutions and adopt innovative business models tailored for Sudan. Emphasis should be on use of local energy resources, ensures adequate return on investment, and provide income generation opportunities through productive uses.
3. Create innovative partnerships between the government institutions, private sector, and local and international financing institutions, with clear focus on promotion, awareness raising, and capacity building to enable these partnerships to create solutions tackling the poverty reduction using the renewable energy technologies.
4. Promote adoption of modern biomass conversion technologies like advanced cook stoves and biogas systems for meeting clean cooking/heating energy needs.
5. Encourage introduction and adoption of biogas technology in rural households as a means of producing clean cooking fuel with appropriate financial support mechanism. Promote conversion of biogas digester solids into compost and its utilization as organic fertilizer.
6. Implement pilot projects of solar drying with the objective of technology dissemination among farmers.

Strategic focus 3:

Enhance energy efficiency in urban areas and strengthen capacity of increased efficient energy in the economy

The following short-term actions are proposed:

1. Support the process of putting in place policy conditions to attract private sector investment in off-grid solutions in rural as well as urban areas.
2. Promote solar PV for large consumers in urban communities by introducing new Power Purchase Agreements (PPAs), or long term leasing arrangements, to fit their unique situation of internal consumption and export the excess electricity to the grid, which will enhance their energy security and well as contribute to shave the daytime peak demand and usual summer shedding.
3. Commence energy efficiency awareness program (residential, commercial & industrial sectors), in addition to embedding energy efficiency component in every renewable energy project.

The following medium-term actions are proposed:

1. Speed up efforts to establish efficient demand-side-management regulations and implementation mechanisms. Implement all the recommendations of the National Energy Efficiency Action plan (NEEAP) of Sudan and establish related institutions.
2. Ensure that energy efficiency is an integral part of universal energy access policies by strategically focusing on specific sectors such as housing, transport and industrial and manufacturing sectors and including efficient lighting solutions (LEDs), heating and cooling, energy efficient appliances, industrial motors, building materials, advanced biomass cookstoves, etc.

The following long-term action is proposed:

1. Ensure energy efficiency is an integral part of sustainable development of the economy through incentivizing technology transfers of energy efficient technologies, introducing energy efficiency labelling programs and implementing demand-side-management programs.



Theme 2: Transform the Energy Sector as a Means for Sustainable Development

A comprehensive package of technical and financial assistance will be needed to transform Sudan's energy sector.

This will involve the development of risk management strategies that effectively promote public and private investments into scaled-up sustainable energy solutions. To achieve this, three strategic focal areas are proposed that aim to strengthen institutional capacity for evidence-based planning; introduce a process for de-risking of sustainable energy investments; build capacity around energy data development and knowledge management; and integrate renewable energy in national development planning.

Combined these actions will help to transform Sudan's energy sector into an engine for sustainable development. Each of these focal areas is aligned with the UNDP's Derisking Renewable Energy Investment (DREI) initiative which introduces an innovative, quantitative framework to assist policymakers in developing countries to cost-effectively promote and scale-up private sector investment in renewable energy and off-grid solutions (UNDP, 2013; UNDP, 2018). The specific set of actions outlined below will be critical in achieving the goal of increased energy sector transformation.

Strategic focus 1:

Strengthened institutional capacity for integrating energy in evidence-based development planning

The following short-term actions are proposed:

1. Finalize and pass pending legislation on the Electricity Law, the Renewable energy law, the Private Public Private Partnership Act, the Feed in Tariff (FIT) policy, and the Independent Power Producers (IPP) policy. This is response to the presence of significant delays in approvals/enactment of Acts, legislations and policies.
2. Set up a formal inter-ministerial coordination framework and initiate and develop space for national private sector-government dialogues.
3. Initiate a revision of electricity tariffs to ensure that subsidies are rationally allocated to serve the poor without sacrificing the profitability of the sector in general, which will increase the bankability of the projects and make the Sudanese electricity market more attractive for big investors, minimizing the burden on the government and lowering electricity costs.
4. Convene local and international industry for consultations of best ways to scale up financing of energy efficiency and renewable energy investments in Sudan.

The following medium-term actions are proposed:

1. Scale-up the existing renewable energy capacity development activities. Sudan has enough experience and expertise in implementing renewable energy projects such this this important next step is feasible with existing institutional capacity.
2. Support the strengthening of effective integration of sustainable energy measures in public agencies action plans in the context of existing governance and leadership structures, revisions and enhancement of NEEAP and NREAP to optimise collective outcomes and develop tools for enabling deployment of sustainable energy initiatives, identifying funding opportunities for projects and activities and following up on NEEAP and NREAP.
3. Rationalize electricity tariffs considering affordability and sectoral focus (consumers). Prepare plans for introducing targeted energy subsidies through direct cash transfers to poor and low power consumers.
4. Lift electricity tariff subsidies gradually for high electricity consumption customers. Supported by new policies, apply FiT for IPP projects and net-metering for urban high consumers (solar roof-top), to attract investments from investors as well as consumers, and help shaving daytime summer peak.
5. Promote IPP projects in grid-connected solar PV and wind energy systems. Sudan has already previous experience in dealing with IPP projects such as the Nyala IPP project, which is a 30 MW diesel generation plant. This experience would greatly help Sudan in going forward.

The following long-term actions are proposed:

1. Commence domestic manufacturing projects supporting renewable energy for rural communities (small wind turbines, solar cookers, biogas units, advanced cookstoves, etc.). This should be carried out in collaboration with research and development (R&D) institutes and the Ministry of Industry and Investment.
2. Support activities to exchange innovative financing ideas that could be scaled up at national levels by supporting poverty reduction, gender empowerment, and building resilience focusing on the generation and sharing of knowledge and collecting data to inform policy and innovative financing. This would include by promoting innovative start-ups for scaling up of local and international finance to support sustainable energy actions and shift the trajectory of development towards a more sustainable and resilient future.
3. Develop entrepreneurship and skill development programs for industrialization through micro-, small- and medium enterprises (MSMEs). Focus could be on agriculture-driven food processing enterprises, small-scale energy solution, repair and maintenance services, etc.
4. Promote use of modern energy carriers in the industrial sector. Particular emphasis should be on promoting electricity use in industrial and agriculture sector through favorable policies.
5. Expand the electricity transmission and distribution network considering the potential for renewable energy sources (solar PV and wind energy) including under-served regions (Darfur and Kordofan).

Strategic focus 2:

Policy process initiated for de-risking of sustainable energy investments

The following short-term action is proposed:

1. Based on a priority ranking, take steps to provide final approvals for pending drafts of several laws, regulations and policies. These have necessary ingredients for de-risking energy investments by the private sector.

The following medium-term actions are proposed:

1. Explore ways of developing policy interventions to expand the role of Sudan diaspora community in energy investments.
2. Implement UNDP's de-risking renewable energy investment tools with support from UNDP. Both policy and financial de-risking is critical for attracting private investors and enhance bankability of projects.
3. Implement small to medium-sized projects (solar, wind, biomass) as promotion projects utilizing environmental funds from (GEF, GCF, UNDP, AfDB, and others) to showcase the technology to local investors and banks as well as medium industries to overcome the novelty barriers.

The following long-term actions are proposed:

1. Adopt a coherent and holistic strategy towards private sector engagement in the energy sector through supportive policies, transparent and efficient institutions, faster clearances and enhanced bankability of projects.
2. Diversify electricity generation capacity to natural gas-based power generation systems. Sudan has un-utilized reserves of natural gas and it is being currently flared into the atmosphere causing pollution and economic losses. Shifting from oil-based thermal to natural gas-based thermal power generation provides several benefits such as lower carbon emissions, more efficient, lower economic costs and more importantly utilization of resource that is being wasted.
3. Launch strategic partnerships between government, UNDP, civil society and academia to promote energy uptake. This should comprise the following categories: alternative energy, LPG uptake, microfinance for energy appliances, Fuel Efficient Stoves, SME support, solar PV, kilns and bakeries.

Strategic focus 3:

An enhanced capacity developed for disaggregated sustainable development data and knowledge management

The following short-term actions are proposed:

1. Improve the data and information infrastructure. The lack of reliable data is the biggest challenge for Sudan. The available data is very old, inconsistent and unreliable. The important first step is to verify the available data on record, check for consistency and correctness, and integrate databases of different ministries, departments and agencies and establish a single large database.
2. Verify and correct the data related to Sudan that are reported by various international agencies and databases. Publicly available online and open access databases are provided by United Nations, World Bank, IEA, IRENA, and others.

The following medium-term actions are proposed:

1. Strengthen the capacity for monitoring, tracking progress and data management within the Ministry of Energy and Natural resources.
2. Build capacities and promote data and knowledge sharing and skills.
3. Adopt multi-tier framework developed by World Bank/ESMAP for measuring and monitoring energy access for electricity services and clean cooking.
4. Establish and apply energy auditing program for industrial sector. And apply energy efficiency policies for AC and lighting market (imports).
5. Establish training centers for capacity building in renewable energy technologies at the state level.
6. Approve well-qualified small rural industries for the production of appliances, accessories and other tools and devices required for implementation of renewable energy projects.

The following long-term action is proposed:

1. Develop an open access and online database that report data on all the aspects of energy sector and national economy.

Strategic focus 4:

Integration of renewable energy in national development planning

The following short-term action is proposed:

1. Map biomass resources. This is of utmost importance for converting it into modern energy carriers such as electricity, biogas and bioethanol. Initiate national level surveys and analysis of satellite images to assess biomass resources.

The following medium-term action is proposed:

1. Add or expand i) current hydro power generation capacity by exploiting micro-hydro options; (ii) grid-connected medium capacity wind power generation systems from government own funds; and (iii) solar PV generation system in grid-connected and off-grid modes (micro-grids, hybrid systems).

The following long-term actions are proposed:

1. Promote large-scale grid integration of renewable energy power generation capacity. This is essential given that Sudan is blessed with high potential for solar and wind power generation. Private sector initiated large-size solar PV and wind energy power plants are to be prioritized.
2. Exploit wind energy potential in the Northern state as well as the River Nile state since studies proved that both states enjoy wind speed higher than 7.0 m/s optimum for project development.
3. Promote grid-connected Solar PV for own use (stand-by supply) and grid supply by industries.



Theme 3: Provide Energy Services for Resilience Building and Recovery from Socio-economic and Environmental Shocks

A comprehensive package of energy services will be needed to build resilience in Sudan's rural communities, especially for those communities that are recovering from socio-economic and environmental shocks including conflicts, climate change induced disasters such as droughts and flooding. This will involve address key challenges such as food insecurity, malnutrition, health, education and rural poverty in hazard-prone and previous conflict areas of Sudan. To achieve this, two strategic focal areas are proposed that aim to integrate energy services in sustainable recovery planning and programming; and deploy solar energy solutions for basic and productive energy services. Together, these actions will help to build resilience against climatic and other shocks while safeguarding livelihoods especially of rural communities recovering from past resource-based conflicts. The specific set of actions outlined below will be critical in achieving the goal of resilient rural communities.

Strategic focus 1:

Integrate energy services in resilience building and sustainable recovery planning and programming

The following short-term action is proposed:

1. Promote through enabling policies and incentives, investors, both in the private sector and donor communities, to invest in expanding emergency energy supply for rural areas and pastoral communities for recovery and building resilience.

The following medium-term actions are proposed:

1. Integrate energy access in conflict resolution, peace building, rehabilitation of returnees, stabilization of infrastructure, resilience building and recovery planning/programming.
2. Support the development of policies that gives incentives to use sustainable energy to power and increase the diversification of commercial livelihood activities
3. Ensure access to energy for effective functioning of all government institutions at the local level especially in rural areas such as health care, education and communication services.

There are no long-term actions proposed for Strategic focus 1.

Strategic focus 2:

Deploy solar energy solutions for basic and productive energy services

The following short-term actions are proposed:

1. Deploy renewable energy mini-grids including off-the-shelf decentralized (off-grid) energy options and solutions like solar for irrigation, solar for micro enterprises, solar for social services etc. In some cases, it may entail deploying solutions such as solar lanterns, solar home systems for emergency lighting and mobile charging.
2. Support the capacities of central government, local authorities, the private sector, civil society organizations to enable communities' use of alternative sources and methods to access modern energy services and technologies, clean drinking water and safety and security of women and children.

The following medium-term actions are proposed:

1. Deploy sustainable energy technologies and solutions to develop value chains for livelihoods, strategic livestock and agricultural operations.
2. Create incentives to attract an effective sustainable energy public and private sector investment.

The following long-term action is proposed.

1. Integrate long-term sustainable energy priorities in the resilience building and recovery plans.

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