Energy Infrastructure

Solar Energy in Sudan
Sudan’s economy was hit hard since the southern part of the country declared independence in July 2011, taking with it about 75% of the country’s oil output.

Sudan’s primary energy supply was estimated as 14.8 million tons of oil equivalent of which biomass resources accounting for 62%, fossil fuels 34% and electricity 4% of total energy supply.

Following the secession of South Sudan in July 2011, Sudan lost 60% of its biomass energy resources, 75% of its oil reserves and 25% of its hydro-power potential.

However, Sudan is currently undergoing a recovery program diversifying its energy generation in renewable energy sector.

Sudan achieved improvements in the energy supply during the last 10 years through the use of indigenous oil reserves and dams construction along the Nile providing much needed hydro-electrical power.

Infrastructure developments have been made in the electrical transmission with recent commissioning of Biomass electrical power plants and continued developments in the telecommunications infrastructure.

Electrical generation has been increasing at a 10% rate from 2005 – 2015 with commissioning of several hydro-electric projects.
Energy Constraints

70% of the population currently has no access to electricity (Energy Situation Analysis Report). Sudan’s population is extremely vulnerable to energy supply constraints.

The National Energy Assessment of Sudan reported that about 73% of the total electrical power is consumed in three states:-

- 45% Khartoum State
- 18% Al Geziera State
- 10% White Nile
- 16% is consumed by Sinar, Red Sea, Kassala, Nile States
- 11% is consumed by 12 states (> 1% for each of Northern State, Blue Nile State, Kordofan States and Darfur States).

Thermal Generation

There are 13 thermal power plants in Sudan with varying types of generation: steam turbines, gas turbines, combined cycle and diesel

The total installed capacity (grid and off grid) is 1,650 MW.
Sudan has five hydro power plants with a total capacity of 1,593 MW.

- Sinnar Power Plant: 15 MW (1962)
- Elgria Power Plant: 17.8 MW (1964)
- Roseires Power Plant: 280 MW (1971)
- Jabel Awlia Power Plant: 30.4 MW (2005)

Due to the electrical energy demand growth the Ministry of Water Resources and Electricity (MWRE) plan to increase the generation capacities with different sources as well as conventional and renewable energy.

The Ministry of WRE also aims to meet the rapid increase in electricity demand to provide mobile gas turbines as fast track projects.
**Current Capacity**

**Figure 1**: Total Power Generation in Sudan 2015

[Pie chart showing power generation sources with Hydro at 64%, Steam at 23%, Combined cycle at 10%, Diesel at 2%, Gas turbines at 0%, and Interchange at 1%. Total Electrical Generation 13,133 GWh.]

**Figure 2**: Total Installed Capacity in Sudan 2016

[Pie chart showing installed capacity with Hydro at 49%, Steam at 31%, Combined cycle at 14%, and Diesel at 5%. Total installed Capacity 3,227 MW.]
Solar Energy in Sudan

Solar energy, averaging 6.1 kWh/m² is particularly significant in Sudan, and is considered one of the best solar resources globally. It is well distributed throughout the country, and high potential in the Darfur Region, facilitating the provision of energy services to rural settlements that are unlikely to be reached by modern energy infrastructure (electric grid and pipelines).

Figure 3: Solar Energy Resource Map
This renewable energy potential is increasingly recognized by the Government: the Comprehensive Renewable Energy Master Plan (2015) has its specific objectives;

- an increase in the share of renewables in Sudan’s energy balance and increased access to renewable electricity services in rural areas
- and the role of solar (PV) technology in achieving this.

The particular role that solar energy can play in lighting is also receiving considerable attention: a 2011 assessment of national GHG mitigation options by the Higher Council for Environment and Natural Resources specifically identifies PV for rural electrification as one of six priority PV applications.

**Socio-Economic Impacts of using Solar Energy**

- **Access to energy** is a critical enabler for economic and social development. Once communities have access to modern energy services, the impact on human development is significant: from cleaner indoor air and improved health to more income generating opportunities and more time for other pursuits.

- **Access to clean, affordable, sustainable energy** is thus an enabling factor for economic development and poverty reduction as well as for achievement of internationally agreed development goals, including ensuring environmental sustainability and promoting gender equality. At the same time, access to energy services can be argued to be a human right in itself.
• Provision of lighting extends the working day and thereby the time available for engaging in income generating activities for women who often face substantial time constraints due to domestic work obligations. Access to energy based technologies enhances labour productivity and increases the time available for engaging in productive activities outside the household.
Sudan Ministry of Water Resources and Electricity Plan

Figure 3 – Renewable Energy, 2020 Target – Medium Term Plan

Figure 4 – Renewable Energy, 2031 Targets – Long Term Plan
In 2031, Renewable Energy will represent 29.3% of the Installed Capacity. 13.6% share of Electricity Generation.
Rural Electrification Programs

**Ministry of Water Resources and Electricity (MWRE):** The MWRE is implementing a large solar project for rural electrification. The project aims to provide standalone solar systems (lighting and TV sets) for 1.5 million households in rural Sudan by 2016. Currently the pilot project phase is implementing in 5 States. The involvement of the MWRE is to build on the experiences further to scale-up the solar project by inclusion of more villages in Darfur region in this solar rural electrification project.

The project aims to provide the electricity service to the households in rural areas far from the grid by installing Solar Home Systems.

- **Target:** Installation of 1.1 million 50-100-200W solar home system (SHS)
- **Period:** 2015-2031
- **Objective:** Provide electricity for 5.5 million, 26% of Population in Rural Areas
- **Budget:** Approximately USD $600 million

Pilot Project for 100 Solar Home Systems in 4 different states has been implemented. Currently 10,000 Solar home systems are currently being implemented.
The Darfur Solar Electrification Project is grounded in the outcome of the Doha Document for Peace in Darfur (DDPD) signed in 2011 between the Government of Sudan and the Darfur Regional Authority (DRA), which built the foundation for strengthens the peace and development processes.

The main output of the project is to install Solar Photovoltaic (SPV) systems in different community services centres (provide “solar systems for schools, health clinics, streets, police stations, women centres and water pumping) for 70 villages in Darfur. The project contributed to the achievement of pillar II of the Developing Darfur: A Recovery and Reconstruction Strategy (DDS).

The project provides direct benefits to 7,000 returnee’s households who are settled in the selected villages. The project will indirectly benefit about 20,000 - 35,000 returnee households in the satellite villages (3 to 5 satellite villages surrounding each centre village where solar systems will be installed) which share the some services such as education and health services.
According to the demographic data, the direct and indirect beneficiary of population is about 35,000 and 150,000 respectively.

Different solar systems procured and installed in 70 villages (7,000 households) including community services such as schools, health clinics, streets, police stations, women centres and others: The project is planning to install 8,120 solar systems of different types and sizes which can be grouped into 5 categories including DC systems (suitable for lighting systems for schools mosques and small service centres), AC systems (suitable for running computers, fridges, communication and satellite TVs), Street lights, mobile solar lamps, and solar pumps.
# Types of Systems installed by the Darfur Project

## Table 1: Types of Solar systems installed by the Initiative in 2011

<table>
<thead>
<tr>
<th>#</th>
<th>Systems installed</th>
<th>Type of services provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>School (evening classes + computer)</td>
<td>Lighting + computers</td>
</tr>
<tr>
<td>2</td>
<td>Mosques</td>
<td>Lighting + Loud speaker</td>
</tr>
<tr>
<td>3</td>
<td>Police station</td>
<td>Lighting + communication system</td>
</tr>
<tr>
<td>4</td>
<td>Health Centres and Hospital</td>
<td>Lighting + Basic medical tools + vaccine fridges</td>
</tr>
<tr>
<td>5</td>
<td>Youth Club</td>
<td>Satellite TV + lighting</td>
</tr>
<tr>
<td>6</td>
<td>Street lighting system</td>
<td>10 street poles</td>
</tr>
<tr>
<td>7</td>
<td>Women development</td>
<td>satellite TV + lighting</td>
</tr>
<tr>
<td>8</td>
<td>Solar water pumps</td>
<td>Water pumping</td>
</tr>
<tr>
<td>9</td>
<td>Mobile Lantern lamp</td>
<td>Lighting</td>
</tr>
</tbody>
</table>

*Source: The National Energy Research Centre (NERC) report 2011.*

The table above presents the classification of system type, initially planned to be installed in selected pilot areas in the five states of Darfur.

## Table 2: Systems to be Installed

<table>
<thead>
<tr>
<th>State</th>
<th># of Villages</th>
<th>Estimated direct beneficiaries</th>
<th>Types and number of solar system to be installed</th>
<th>Total number of systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Schools</td>
</tr>
<tr>
<td>North Darfur</td>
<td>14</td>
<td>3,150</td>
<td>3,850</td>
<td>28</td>
</tr>
<tr>
<td>South Darfur</td>
<td>14</td>
<td>3,150</td>
<td>3,850</td>
<td>28</td>
</tr>
<tr>
<td>East Darfur</td>
<td>14</td>
<td>3,150</td>
<td>3,850</td>
<td>28</td>
</tr>
<tr>
<td>West Darfur</td>
<td>14</td>
<td>3,150</td>
<td>3,850</td>
<td>28</td>
</tr>
<tr>
<td>Central Darfur</td>
<td>14</td>
<td>3,150</td>
<td>3,850</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>70</strong></td>
<td><strong>15,750</strong></td>
<td><strong>19,250</strong></td>
<td><strong>140</strong></td>
</tr>
</tbody>
</table>
Sustainability and Value for Money

The application of solar energy technologies in Darfur to improve the accessibility to rural energy services such as illuminating the darkness, water pumping for domestic water supply and irrigation and cooling for medicinal purposes is vital for the development of the region. This is because the other conventional alternatives (Grid connection & Oil products) of supply such energy services are quite difficult due to remoteness and poor infrastructure.

As shown that there are only 5 cities supplied by thermal plants which have limited capacity and are not sufficient to be extended outside these cities. Poor roads network in the region presents an additional challenge for the transportation of oil products.

Solar-powered street lighting is currently being installed in villages provide an opportunity for improving security and movement of persons, especially for women and children, in IDP camps and rural villages. Solar lighting sets in community centres, women’s centres, health posts and police stations play a major role in extending the useful life of these buildings and make it possible to utilise these buildings after day light hours. It would also be seen as a major “peace dividend”.

The provision of electrical services through conventional sources of energy such as diesel generators or the extension of the grid is very difficult and costly option. Generally, modern energy services are unavailable and/or unaffordable to the majority of the Darfur states’ population.

For example local diesel generators provide electricity services at a cost of SDG1.4/kWh.

Calculated price of power generation for a solar system provides a cost of SDG 0.5/kWh (life cycle cost).

The cost of electricity generation through the solar system is approximately a third of the cost of diesel generation.
## Table 3: Results Framework

<table>
<thead>
<tr>
<th>JP/Project Title</th>
<th>Darfur Solar Electrification Project</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DDS Pillar</strong></td>
<td><strong>PILLAR II: RECONSTRUCTION</strong></td>
</tr>
<tr>
<td><strong>DDS Objective</strong></td>
<td>Pillar II, obj: Increased access to electricity services</td>
</tr>
</tbody>
</table>

### Relevant DDS Pillar Priority:

<table>
<thead>
<tr>
<th>JP/Project Outputs</th>
<th>UN Organization</th>
<th>Other Implementing partner(s)</th>
<th>Performance Indicators</th>
<th>Baseline</th>
<th>Target</th>
<th>Means of Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Different solar systems procured and installed in 70 villages (7,000 households), including community services such as schools, health clinics, street lamps, police stations, women centres and others</td>
<td>UNDP, UNDO, WHO</td>
<td></td>
<td>1. Number of villages equipped with solar systems 2. Number of services in each village equipped with solar systems 3. Population benefited 4. Percent of benefited women from the total population 5. Number of pupils benefiting from school lighting, sex-disaggregated</td>
<td>30 villages are electrified by solar system in 2003 by NERC as part of the presidential initiative to electrify the broader villages</td>
<td>70 villages</td>
<td>Monitoring reports on physical installation / Evaluation reports</td>
</tr>
<tr>
<td>2. Technical assistance provided to ensure that installed solar systems are operated and maintained by the users</td>
<td>UNDP, UNIDO</td>
<td>MWRE, NERC, DRA</td>
<td>1. Numbers of PV courses conducted in the vocational training centres 2. Number of trainees on the operation and maintenance (disaggregated by sex) 3. Number of vocational training students graduated with PV specialisation.</td>
<td>All the solar project installations were accompanied by community training. The PV curriculum will be developed for the vocational training centre in Darfur State.</td>
<td>70 villages</td>
<td>Project quarterly and annual Reports &amp; Studies</td>
</tr>
<tr>
<td>3. Enabling environment created and scaled-up plan implemented through establishment of financing and dissemination mechanism</td>
<td>UNDP, UNDO, WHO</td>
<td></td>
<td>1. Conducive Policies proposed 2. Scale-up plans for Darfur States formulated and operationalised</td>
<td>MWRE developed a national plan to electricity 1.5 million households by 2016 through provision of standalone off-grid solar systems.</td>
<td>5 states of Darfur</td>
<td>Documents of formulated policies and plans</td>
</tr>
</tbody>
</table>
Conclusion

Approximately 70% of the Sudanese population is not connected to the electricity grid – the majority of those being in the rural areas.

The use of Solar energy provides a great opportunity to generate electrical power to regions that are marginalised from the current electricity grid.

The hot and sunny year round Sudanese climate makes sunlight an abundant resource for the capture of sunlight to produce energy.

With 75% of Sudan’s oil reserves lost to the South Sudan in the secession- Solar energy offers a cost effective and viable option in meeting the energy supply demands for the future.

Cost-effectiveness

- Principles of whole life costing (WLC) should be applied. Solar Panel system design should aim to provide the most cost-effective solution, particularly in terms of maintenance requirements. This requires consideration of whole-life costing of alternative options.
- Most appropriate systems should be adopted to meet Sudan’s weather conditions and usage behavior.
  The three principles behind the selection of solar photovoltaic supplier are:
  - Sustainability;
  - Level of service;
  - Cost-effectiveness.
KIS Consultancy

KIS Consultancy

KIS has strong knowledge of the region and a wide network of experts that enabling to provide up-to-date informed insight.

We aim to develop simple and sustainable solutions that can be implemented and maintained with local content and international expertise.

Through international partnerships and collaboration with local academic institutions that promote solar energy research and development, KIS Consultancy believes that true sustainable development and enrichment of renewable energy alternatives can take place across the region.
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