بسم الله الرحمن الرحيم

Ministry Of Energy & Mining
General Directorate For National Energy Affairs

Sudan Energy Situation In House-Hold Sector

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Introduction

1-1 Background :-

Sudan is the largest country in Africa with an area of 2.51 million square kilometers (about one million square miles). It lies between latitudes 3 ° and 23 ° N and longitude 21° and 39° E.

Sudan's climate is very hot, every part of the country experience maximum average temperatures of over 38°C during several months of the year and many parts experience these temperatures at all times of the year. In the north, the heat is tempered by low humidity during much of the year. Also Sudan has a tropical continental climate for narrow fringe a long the Red Sea coast.

According to the 1993, last census the total population of Sudan estimated to be about 25.558 millions inhabitants. The annual population growth rate is about 2.88 % and the population density is less than ten persons per square kilometer.

Table No. 1.1
Total Population in the Sudan

Region	Total Population (millions inhabitants)
Northern State:-	
Northern Region	1.298
Central Region	5.433
Eastern Region	3.067
Kordufan Region	3.323
Darfur Region	4.638
Khartoum Region	3.512
Southern State:-	
Bahr ElGazal	1.913
Upper Nile	1.258
Equatoria	
Total	25.588

Source:- Central Bureau of Statistical & UNFPA, Statistical Year Book 1999 Khartoum, Page 27.

According to the medium scenario population is going to grow as (in table 1.2)follows:-

Table No. 1.2

Expected Population Growth Rate
(1993 - 2018)
Medium Scenario

Year	Growth Rate %
1983/93	2.88
1993/98	2.73
1998/2003	2.63
2003/2008	2.53
2008/2013	2.4
2013/2018	2.22

Source: Statistical Department, Khartoum

Sudan is rich in water and land resources. Water resources is estimated at 50 Million cubic meters, this including the River Nile and it's attributers, ground water beside the rain which ranges from 0 ml in the Northern desert to a bout 1400 ml in the Equatorial region.

The land used in the country is classify in the four main categories these are:-

Category	Arable land	Pasture	Forest	Others
Area (000 Ha)	8400	29940	91560	38220

Source: Statistical Department, 1993 Census, Khartoum 1994, Page 7.

Sudan is also viewed as one of the potentials richens countries especially in livestock beside water and land. In 1997 the livestock estimation is as follows:

Unit In (000) Peace

Type	Cattle	Goats	Sheep	Camels	Total
No. of Head	33102	36037	39835	2936	111910

Source:- Central Bureau of Statistical & UNFPA, Statistical Year Book1999, Khartoum, Page 82.

1.2 General Features Of Energy Sector :-

- **Increase gap between supply L demand .**
- **High demand on**
- **Low efficiency in consumption device**

- **Household is the largest consuming sector of biomass and electricity.**
- **Low afforestation rate.**
- **Fuel-wood is common in H-Hold and service sectors and small industries.**
- **Fuel prices are rapidly increasing include fuelwood and charcoal prices.**
- **Rapid depletion of forests in Khartoum , Central and Eastern States.**

2. Energy Sector In Sudan:-

2. 1 Energy Policies & Strategies :-

Energy policy within the overall development policy of the National Comprehensive Strategy (1992 – 2002) , has the following objective :

- **To provide an adequate and reliable supply of energy from local resources to support sustainable devlopment.**
- **To conserve the environment through efficient and optimal utilization of local resouces, especially forests, and to promote tree-plantating activites. The solution of the energy problem should not be at the cost of the deterioation of natural resources.**
- **To conserve all energy types so as to generate the highest economic value for energy and minimize the cost to the economy.**
- **To develop the energy sector institutions to ensure coordination between consumers and producers.**
- **To develop and promote local and/ or adapted energy technologies particularly in the field of renewables (RETs).**
- **To train qualified and adequate staff at all levels to facilitate the development of energy sector.**

2.2 Energy Resources :-

2.2.1 Non-Commercial Resources

Non – commercial resources includes fuel wood (which composed of fire wood and charcoal) beside agricultural residue and animal dung are utilized as fuel sources clearly dominating Sudan final energy consumption 66% and represent 78.6% from the energy supplies in 1997.

Early estimates dating from the 1950s and 1960s indicated a productive forest area of 455,000 square kilometers. This area was to contain a growing stock volume of 1,28 million cubic meters. Average stocking 22.2 – 28.6 m. cub./ha ranging from 150 m. cub./ha in the forests in the south to less than 1 m. cub./ha in the desert areas.

The following studies using early 1970's landsite photo –imaginary, estimates the total area and volume of Sudan's Forest resources to be about 1.08 million hectors and 1.96 million cubic meter respectively,

about 70% of this is located in the Southern States and the forest area decrease towards the north of Sudan.

Other biomass resource agriculture waste (include crop residue which composed of cotton stocks, groundnut shells, bagasse and animal dung) are the most eligible sources for non – wood biomass energy.

2.2.2 Renewable Energy Resources

2.2.2.1 Solar Energy:-

Potentiality of solar radiation on a horizontal surface ranges between 6.9 GJ/m^2/Yr. in the south of Sudan to 10.1 GJ/m^2/Yr. in the north , equivalent to 436-639 W/m^2 (see appendix for more details).

2.2.2.2 Wind Energy:-

Ministry of Energy & Mining representing by it's National Energy Administration (NEA) analyzed available wind characteristics data for design of wind energy conversion system. In the North around Dongla the wind energy potential shows a density in excess of 400 W/m^2 285-380 W/m^2

2.2.2.3 Mini-Hydro Energy:-

A number of prospective areas have been identified by the surveys and studies carried for exploration of mini-hydro power resources in Sudan.

The southern area has a potential for mini-hydro more than 67000MWh, the sites of Jebel Mara area has potential exceeding 13785 MWh and with additional expecting potential is in the Gazira and Managil irrigated canals equal to 44895 MWH .

2.2.2.4Geothermal Energy

Geothermal heat is constantly disputed from sources within the earth crust in regions where volcanic activity have taken place in relatively recent times.

A tectonic movement accompanied by intensive volcanic activity took place in the Red Sea Area about 25 million year ago. These conditions renders the area a prospect for geothermal exploitation . Other parts of the country were affected by volcanic complex that is likely to process geothermal heat source stored at a relatively shallow depth i.e. Red Sea Area where the volcanic complex covers an area of 10000sq.kmwith an elevation of 3020m above sea level. Hot springs and fume roles have been observed on the flanks. Also in Jebel Marra where volcanic complex processes an important geothermal heat source suitable for electric power generation.

2.3 Energy Balance :-

In 1998 the estimated total energy supply was about 14.595 Million Tons of Oil Equivalent (TOE) . Biomass Table (2.3.1) . Biomass (wood, animal waste) and the agriculture residues remained the major contributor with the share of 88% (83% wood and 5%) rsidues). This is a clear indication of continuos exploitation of the country,s forest resources . Petroleum and Hydro provided 12% and 1% respectively of the total energy supply.

Table(2.3.1)
Estimated Energy Supply 1998

Resource	Supply (000TOE)	%
Wood	12152	83
Residues	798	5
Petroleum	1555	11
Hydro	90	1
Total	14595	100

Source :National Energy Affair Directorate ,Ministry of Energy & Mining.

On the other hand consumption estimates during the same period(1998) was about 7790 thousand Tone of oil equivalent (000 TOE), table (2). The difference between supply and consumption which is 6805(000TOE) (46.6%) reflects the losses and the low efficiency of utilization of energy resources (only 53.4%) . The most of the losses occurring in the process of converting wood to charcoal where more than 6.4 million TOE has been lost.

On sectoral basis ,household sector is the largest consuming sector with the largest share 69%. Biomass(wood, charcoal and residues) represents 98% of the total energy consumption in this sector and 81% of the total Biomass consumption about 46% of the total electricity consumption. Services sector consumed 12% of the total energy consumption about 89% come from biomass and 28% of the total electricity consumption. Services consumed only 6% of the total petroleum consumption in 1998.

The transportation sector constitutes 694 (000 TOE) all of it in the form petroleum products of the total energy consumed in 1998. It absorbed more than 60% of the total petroleum consumed in 1998.

The industrial sector consumed only 578 (000 TOE) (8%) of the total energy consumed during the same year. It consumed only 6% of the

total biomass consumption and 15 % of the total petroleum consumed and 23% of the total electricity.

The agriculture sector consumption was only 182 (000 TOE) (2%) of the total country energy consumption in 1998.Most of the consumption (98%) was petroleum products for water lifting in agricultural operations. The rest (2%) is electricity, which is used for water lifting only.

2.4 Total Energy Consumption:-

Table No. (2.3.1)
Energy Consumption By Sector
(000 TOE)

Sector	H-Hold	Services	Transport	Industry	Agriculture	Total
Petroleum	22	69	694	177	180	1142
Electricity	53	33	-	27	3	116
Wood	2522	691	-	217	-	3430
Charcoal	2150	154	-	-	-	2304
Agriculture Residue	641	-	-	157	--	798
Total	5388	947	694	578	183	7790
%	69	12	9	8	2	100

Source : Ministry of energy and mining , National Energy Affairs Directorate.

3. House-Hold Sector :-

3.1 Pattern of Energy Consumption:-

Unlike other consuming sectors , the household sector has unique supply demand characteristics . These are mainly summarize in the following :-

- **The h-hold sector consist of many individual users, where there is enormous diversity in the availability and cost of energy supplies, mix of fuels are employed at the level of consumption with different users and different technologies.**
- **Biomass which dominate the household energy supply and consumption is not recorded and mostly the information are estimates or surveys which is costly.**
- **Biomass was specially in the rural areas are competing with other uses such as animal fodder, timber, brick making, wall painting as well as fuels. So the energy problem and solutions must almost invariably be considered within the total content.**

- **Traditional Household fuels and technologies for their use are often diffcult to change, largely because of local of awareness and alternatives are not known and there is no capital even if there is an alternative.**

3.2 Factors Determine Consumption:-

3.2.1 Urban – Rural:-

Substitution options for household energy in Sudan urban dwellings are electricity, LPG , kerosene/ Gasoil and fuelwood.

Rural towns and villages are the viable consumers of wood and charcoal. Due to unavailability or unaffordability of fuelwood in these areas household consumption was shifted towards agriculture residues.

3.2.2 Family Size:-

The increase in energy supplies specially biomass was mainly observed due to population growth which directly related to family size.

3.2.3 Income:-

Highest consumption of LPG and electricity is to be found in higher income households. For wood and charcoal the situation is the reverse, highest consumption by low income group and lowest by high income groups.

3.2.4 Education:-

It is quite evident that the share of illiteracy developed from 2.4% in high income households up to 58.9% in rural low income in systematic matter which shows a direct correlation between level of income, mode of living and education (result of household survey 1994).

In general illiteracy rates are higher among rural population compared to urban, with levels around 40 – 45 % except for Khartoum rural with 21% illiterate.

3.2.5 Occupation:-

Occupation pattern are different in urban / rural areas . Housewives consider themselves unemployed, through they are occupied by household management and children raising (specially in rural area)are active in farms assisting their husband.

3.2.6 Energy Consumption Tables (Rural – Urban)

Table No. (2.3.6.1)
Per Capita Energy Consumption In TOE / Annum

Fuel Type	Semi Desert		Low Rain Fall Savanna	
	Urban	Rural	Urban	Rural
Firewood Charcoal	0.076	0.069	0.063	0.047
LPG	0.013	0.0006	0.012	0.0004
Kerosene/ Gasoil	0.006	0.005	0.003	0.0008
Agric. Residue & Animal Dung	-	0.0074	-	0.02
Total Per Capita/annum	0.095	0.082	0.078	0.0682

Source :- African Development Bank , Domestic Energy Consumption Its Impact on The Environment .Khartoum, Dec.1994.

Table No. (2.3.6.2)
Per Capita Consumption of Fuels by Income Group

Type Of Fuel	Unit	Urban			Rural		
		H	M	L	H	M	L
Firewood	Kg	0.011	0.046	0.098	0.123	0.224	0.224
Charcoal	Kg	0.487	0.478	0.335	0.345	0.387	0.247
LPG	Kg	0.131	0.131	0.018	0.056	0.013	0.001
Kerosene	Gallon	0.001	0.001	0.005	0.004	0.008	.0055
Electricity	TOE	0.147	0.147	0.03	0.03	0.015	-
Residues	TOE	-	-	-	-	0.03	0.03

Source :- African Development Bank , Domestic Energy Consumption Its Impact on The Environment .Khartoum, Dec.1994.

Petrleum consupmtion in house- hold sector is mainly consumed in for lightining by using kerosene and gasoil lamps LPg is used in household for cooking . The last 5 years reflect increasing consumption of LPG in household, due to encourgment investment policies in this area. Table (2.3.6.3) follows show that LPG quantities was increase tripled times in1999 to 1985 consumption.

Table No. (2.3.6.3)

Petrleum Consumption In House – Hold Sector

Year	H-Hold Consumption	Total Petroleum Consumption	%
1993	23859	1214892	2%
94	20603	1444057	1%
95	22144	1352086	2%
96	32004	1359672	2%
97	33179	1443520	2%
98	39362	1348872	3%

Source :- Ministry of Energy & Mining, Khartoum , Sudan,1999.

Urban household consumption from electrcity sector is about 43 - 44% according to total electricity supplies from 1989 –1998 data.

The main consumption is due to lighteng, refregeration and ironing and a low percentage for cooking (see table 2.3.6.4 follows).

Table No. (2.3.6.4)

Total Electricity Consumption In House-Hold Sector (000 TOE)

Year	H-Hold Electricity Consumption	Total Electricity Consumption	%
1989	36.72	83.42	44%
90	46.96	106.64	44%
91	47.64	108.27	44%
92	48.16	109.39	44%
93	47.39	107.76	44%
94	47.9	108.88	44%
95	50.83	117.05	43%
96	54.61	124.1	44%
97	50.83	115.58	44%
98	50.65	115.07	44%

Source :- Ministry of Energy & Mining, Khartoum , Sudan,1999.

Table No. (2.3.6.5)

Total Biomass Consumption In House-Hold Sector (000 TOE)

Year	F. Wood	Charcoal Consumption	Agricul. Residue	Total H- Hold Consumption	Total Biomass	%
1989	2887.8	1443.9	48.1	4379.8	5177.8	85%
90	2963.8	1481.9	49.4	4495.1	5336.2	84%
91	3041.7	1520.9	50.7	4613.3	5497.7	84%
92	3121.7	1560.9	52.0	4734.6	5662.5	84%
93	3187.9	1593.9	53.1	4834.9	5805.5	83%
94	2815.6	1279.8	511.9	4607.3	5556.9	83%
95	2889.6	1313.5	525.4	4728.5	5720.3	83%
96	2965.7	1348.0	539.2	4852.9	5886.9	82%
97	3043.7	1383.5	553.4	4980.6	6056.9	82%
98	3123.7	1419.9	567.9	5111.5	6230.4	82%

Source :- Ministry of Energy & Mining, Khartoum , Sudan,1999.

Table No. (2.3.6.6)

LPG Consumption In House-Hold Sector (000 TOE)

Year	MT	TOE
1985	7564	8169.12
1986	9724	10501.92
1987	9839	10626.12
1988	10140	10951.2
1989	10579	11425.32
1990	12849	13876.92
1991	11640	12571.2
1992	13260	14320.8
1993	12139	13110.12
1994	12491	13490.28
1995	15197	16412.76

In Sudan rural constitute about 70% of population surveys refelected that rural are depending upon fuelwood and charcoal rather for domestic use. Also studies in 1985 showed that the gas share within household consumption is about 10%. A sharp jump occurred during the last 15 years , where the government policy encouraged private investment in LPG.

The consumption of LPG is almost tripled in 1999 compared to 1985. This indicate new trends in energgy vconsumption of this sector.

Table No. (2.3.6.7)

Final End Use Consumption In House-Hold Sector By Activity (Kilogram)

Activity	Urban		Rural	
	Kgm.	%	Kgm.	%
Cooking	1.88	65.51	3.07	84.34
Lightening	0.30	10.45	0.36	9.89
Referegeration	0.33	11.50	0.00	0.00
Other	0.36	12.54	0.21	5.77
Total	2.87	100	3.64	100

Source :- Household Energy Consumption Survey , For ADB ,1992.

Table No. (2.3.6.8)

House-Hold Consumption By Fuel Type (000 TOE)

Activity	Urban		Rural	
	Kgm.	%	Kgm.	%
Charcoal	1.46	51.05	1.88	51.37
Firewood	0.22	7.69	1.33	36.34
LPG	0.38	13.29	0.00	0.00
Kerosene	0.02	0.70	0.11	3.01
Gasoil	0.04	1.4	0.33	9.02
Electricity	2.57	25.87	0.00	0.00
Animal Residue	0.00	0.00	0.01	0.27
Agriculture Rsidue	0.00	0.00	0.00	0.00
Total	2.86	100	3.66	100

Source :- Household Energy Consumption Survey , For ADB ,1992.

4- On Going Activities:-

Sudan 2nd National Energy Assessment :-

The first National Energy Assesment for the Sudan was conducted 1983. Since that a lot of changes were observed concerning supply / demand pattern for energy. Those changes can be summarized into the following:

- **Increase in population & rate of urbanization.**
- **Change in pattern of industrial production.**
- **Expansion in transport network (road)**
- **Exploration in of oil.**

- **Implementation of Federalism in ruling the States (changes in administrative division).**
- **LPG is more popular in urban household.**

The Household energy assessment is being undertaken now as part of the overall energy assessment.

The first assessment undertaken with a support from USAID, provided a good base of methodologies & type of data to be collected for establishing an energy balance of the country & formulating of future plans for the energy sector.

The present household energy survey undertaken aims to achieve the following objectives:

- **The general objective is to establish an information data lose for this sector, to enhance the country overall policies and planning to promote an optimal and sustained development and management of energy source.**
- **The specific objective.**
- **Evaluate the consumption pattern.**
- **Evaluate level of consumption and factors influencing consumption for each type of fuel.**
- **Estimate variation in per capita consumption by states / urbanization / socio-economic groups.**
- **Quantity consumption by end use .**

2- <u>Organization of the Study Work & Implementation :-</u>

- **Preparation for the study started in 1998.**
- **As a sub technical committee of the assessment project a household sectoral committee was nominated, representing experts in household surveys.**
- **The sub committee formulated a plan for conducting the study accomplished includes the following:**
    - **Design the sample for survey.**
    - **Design the questioners.**
    - **Estimated budget and manpower for conducting the survey and analysis of data later.**
- **The plan was reviewed and approved by the National Energy Assessment Technical Committee, and latter by the National Steering Committee.**
- **The implementation of the field work (data collection) was managed by the Central Bareau of Statistics and conducted through it's offices in the different states.**
- **The data was collected for most of the states during the period June / July 1999, In Southern and West Darfur during winter1999.**
- **The two types of questioner were developed the main household questioner, and sample area questioner.**

- **The number of questioners conducted in household were:**
  - **16 Northern State * 1500 = 24000**
  - **3 Southern States * 500 = 1500**

    Total = 25500
- **The data collected was entered into the computers using Access Program.**
- **The sample area questionnaire includes information about prices, weights and volumes of units of fuels used in the area-data of this questionnaire were completed and summarized.**
- **Output tables required to be produced from main household questionnaire were designed**

3- Activities Need to be accomplished Next:

- **To set a program for analyzing the data from main questionnaire.**
- **Presentation of results on a report.**
- **Publishing of the main report.**

5- Efforts Done Within The H- Hold Sector In The Last 15 Year :-

The results of the First National Energy Assessment Project, indicate that household constitute the greater consumer of biomass , electricity 80%, 44% respectively. Most of biomass consumption was noticed to be by rural household for cooking, boiling and baking. For electricity lighting and referegeration are on the top list ironing also noticed to constitute considerable amount of household electricity consumption.

The efforts done include :-

- **Improved Stoves.**
- **Biogas.**
- **Briquetting.**
- **Cabonization.**
- **Energy Plantations.**
- **New Challenges.**

- **Improved Stoves :-**

Efforts with improved stoves started in 1980. A number of stoves were developed those are Elduga stove, Mubkhar stove, Saw Dust stove, beside Jiko stove (Kenyan Type). The plantation rates of those stoves in the household sector is less than 5% . Pthis due to :

1. **Lack of trained artisien.**
2. **Lack of awareness in the area of conservation.**
3. **Lack of finance.**
4. **Some stoves are not practically used.**

5. **Unavailability of ceramic due to limited production since ceramic production required certain knoweledge.**

- **Biogas :-**

Biogas technology was also introduce as a subistitute for fuel wood in household sector. Few units were constructed with capacity ranging from 5-15 m^3 of gas production / day, these are Indian design mostly .

But the experince prooved that the community size units are more economic than small units. New biogas units were developed as a mix between Indian / Chaines type. Still there is a room for biogas , because rural population in Sudan almost live in community "Extended Family".

- **Briquetting :-**

Two types of briquettes we tested in the household :-

1. **Direct Briquettes.**
2. **Carbonized Briquettes.**

- **Direct Briquettings :-**

Briquetting technology introduce in Sudan 1980, by small entreprise using Ground net shells . The factory worked for 2 years and stopped due to transport of Ground net shells from a distance of 10 kilos. In 1988 UNSO with colaboration with Sudan introduced a briquetting machines with capacity of 2 tons/day to produce Agricultural briquettes using groundnut shell in western Sudan since 1990. The produce briquetted shell at 80% of fuelwood. The factory was reported to work below capacity because the market is limited. The transportation of brquittes to other sites implay additional cost . Three other briquetting machines were introduce to Sudan in 1992, 1996. These machines were planted to used cottonstacks and baggase. Marketing of briquetts is a problem because most of the factories were installed according to resourve availability.

A stove was design by a volanteer so as to use briquettes in house-hold sector. It was proved that briquttes can substitute firewood only in rural hoise-holds.

- **Carbonization Briquettes:-**

Carbonized briquetts were also produced in 1988 with German NGEO's GTZ . Cotton stalks were carbonized in kilns and briquetted using mollase as a blinder. The briquettes generate some smoke, but it has limited acceptance within rural housewives, when compared to charcoal which is smookeless fuel.

- **Energgy Platation :-**

During 1984 – 86 the American agency (EDI) in collaboration with Sudan Government financed community foresty project to help small farmers to plant trees to conserve the lqand as well as to satisfy this energy needs.

The project provide loans to about 50 farmers. It was succeeded to plant a considerable area but the work stoped by the end of the project.

- **New Challenges:-**

Sudan become one of the oil exporting countries since August 1999, producing about 150,000 – 180,000 barrel / day.

A complex refinery was constructed in Khartoum, with capacity of 50,000 Ton /day. An amount of 500 Tons/day of LPG is expected to be produced . The demand was estimated at 100 Ton/day. This new situation require certain activites to be taken.

6- What Is Expected From IGAD:-

According to pattern of energy consumption in household sector in Sudan as a results of studies and observations in that sector the following barriers are concluded :-

- **Lack of puplic awareness towords importants of conservation concept**
- **Lack of polcies concered with energy efficiency measures in household sector.**
- **Lack of experts and trained personal in such issues.**

Due to above mentioned barriers and to get the maximum benefit from the recent assessment studies the following assistance are required:-

- **Under taking specialized studies (nomads, specific energy uses in household sector, sesonal survies, …ect.) to enriched the recent conducted survies.**
- **To provide experts to evaluate the collected data and to participate in the analysis phase and report writing.**
- **To train NEA staff program for energy modeling.**
- **To provide stationaries & equipments (computers, printers and software, …etc).**
- **Technical assistance to help in formulation and implementation of conservation policies (effeciency standards/ legislations, pricing,…. etc).**
- **To conduct certain programs to raise the puplic awareness in the area of energy consevation within the household sector.**
- **To provide technical assisstence in the area of research and development within conservation issues.**