SUDAN NATIONAL ENERGY ASSESSMENT

BASE YEAR (1980) ENERGY SUPPLY DEMAND BALANCES AND DEMAND PROJECTION METHODOLOGY

ANNEX I

March 1983

National Energy Administration

Ministry of Energy and Mining

Khartoum
Sudan

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I. INTRODUCTION

This annex contains a detailed account of the information on production and consumption of energy at the national and regional level gathered by the NEA during the course of the Sudan National Energy Assessment. The information contained in this annex is presented in condensed form in the Executive Summary and was used as the basis for projecting energy demand for the next decade. The last chapter of this annex details the methodology employed in the projection of energy demands. As complements to this annex, the assessment will also prepare five sectoral reports: Households, Transportation, Industry, Agriculture and Commercial. These form part of the set of appendices produced for the National Energy Assessment by the staff of the National Energy Administration (NEA) from which the information presented here is obtained. Finally, a set of separate annexes, are being published from reports prepared during the course of the Assessment. These relate to a variety of topics: Population, Forestry and Fuelwood Resources, Transportation Sector Energy, Land Use, Laws governing Importation of Energy-Intensive Consumer Durables, and Debris Accumulation at Roseires Dam.

The chapter that follows contains the overall supply demand balance for the entire country for 1980. This in turn is followed by a Section devoted to each consumption sector, with particular emphasis on explaining data gathering methodology and the fashion in which survey data was extrapolated to regional and national levels. Also included are the kinds of assumptions made for each sector in order to fill gaps left in primary and secondary data sources. A similar treatment is next given to all primary energy resources and electric generation. A separate chapter presents regional balances, paying particular attention to the differences between energy consumption and production at the regional level. Regional analysis of this kind has, to our knowledge, not been made in the Sudan before. It is important given Sudan's official policy of regionalization. The last section of this Annex contains a list of team members and Sector Committees, lists of key sources of secondary information, and lists of other primary and secondary information used for the Assessment.

The energy unit used in this Annex is the tonne of oil equivalent (TOE), which approximates the energy content of one tonne of petroleum and equals 10 thousand kilocalories. Physical units commonly used in the Sudan are tonnes for most solid and liquid fuels, or imperial gallons (I.G.) in the case of petroleum, and Kwh (kilowatt hours) for electricity. Conversion factors commonly used throughout this assessment are included in Tables I-1A and 1-1B.

Table I-1

List of Conversion Factors

Energy Source	TOE/Tonne
Benzene/Avgas	1.05
LPG	1.11
Kero/Jet	1.04
Gasoil	1.04
Diesel	1.02
Furnace Oil	.96
Wood	.43
Charcoal	.72
Agricultural Residues, Households	.32
Agricultural Residues, Industry	.20
Animal Wastes	.25
Vegetable Oil	1.00
Electricity	86.12/Gwh

1 TOE = 41.8 x 10^9 Joules = 10,000 kcal

* One tonne of charcoal is roughly equivalent to 18m^3 of growing wood stock.

Table I-2

Petroleum Products

Product	Imp. Gallon/Tonne
Benzene	308.1
Jet-A-1	281.4
Kerosene	281.4
Gasoil	268.1
Furnace Oil	230.5
Diesel	256.8*

* In Sudan, the term "diesel" refers to a mixture of 70% gasoil and 30% furnace fuel used in some industries and pumps and in power generation.

II. ENERGY SUPPLY DEMAND BALANCES: NATIONAL AGGREGATES

Sudan has an estimated population of 18,680,000 persons (1980) of which one quarter is classified as urban and the rest is rural. There are presently 18 administrative "provinces" which are grouped into seven "regions." It is this group of seven regions upon which regional information is grouped and presented in this report. Table II-1 shows population data for the Sudan for 1980, and estimates of persons per household and number of households by province for urban and rural areas.

Energy consumption in the Sudan in 1980 amounted to nearly 7 million TOE, of which over 5.9 million TOE, or 85%, was in the form of wood, charcoal or other biomass, 0.97 million TOE or 14% was petroleum products and the remainder, less than 1% was hydropower. Tables II-2 and II-3 present 1980 energy consumption, in TOE and original energy units respectively, by sector including electric power. Table II-4 allocates electric power generation by consuming sector. From these tables, it can be seen that:

- Households consumed 93% of all biomass energy, primarily for cooking;
- The transport sector accounted for 58% of total petroleum product consumption, followed by 15% in industry, 10% in agriculture, and 8% in power generation;
- Hydropower accounted for 79% of total electricity generation; and
- Households and industry each represented one-third of total electricity sales, with 11% used by agricultural pumps.

Consumption of petroleum products increased by almost 50% between 1970 and 1980, as shown in Table II-5, with a notable shift toward light products. Furnace oil, to a lesser extent and diesel[1] consumption declined over this period, due primarily to the Sudan Railway's switch from steam to diesel locomotives, deterioration of NEC thermal power stations, and falling cement output. Gasoil consumption almost doubled, reflecting the opening of the Khartoum-Port Sudan highway, growth of mechanized agriculture, growth of industrial and residential self-generation of electricity, and (unexpectedly) a significant substitution of gasoil for kerosene for residential lighting. Benzene and avgas consumption more than doubled, reflecting primarily an increase in passenger cars and mileage traveled and secondarily an increase in air transport activity. The modest growth in kerojet consumption masks a major increase in jet fuel at the expense of household kerosene.

Petroleum product consumption in 1970 largely reflected the real demand for these products, given prices at that time. In 1980 this is probably the case only for furnace oil and diesel. At present official prices, the effective demand for LPG, kerosene, benzene and gasoil is substantially greater than actual consumption. This supply constraint is particularly significant for gasoil, which in almost all uses is an economically productive fuel (Table II-6). Gasoil also is the petroleum fuel with the greatest impact on rural welfare, due to its use for water pumping and for grinding in dura mills.

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[1] "Diesel" in this report refers to a light residual fuel oil. The middle distillate called "diesel" in many OECD countries is referred to as "gasoil" in the Sudan.

Table II-1

Population and Households by Province, 1980

REGION	PROVINCE	URBAN/ RURAL[3]	PERSONS/ HOUSEHOLD[1]	NUMBER OF HOUSEHOLDS	POPULATION ('000)[2]
Eastern	Red Sea	Urban	7.0	32,900	230
	Red Sea	Rural	7.0	50,900	356
	Kassala	Urban	7.0	60,000	420
	Kassala	Rural	7.0	153,700	1076
Northern	Northern	Urban	6.0	8,500	51
	Northern	Rural	5.0	58,800	353
	Nile	Urban	6.0	30,300	182
	Nile	Rural	6.0	70,700	424
Khartoum	Khartoum	Urban	6.5	193,200	1256
	Khartoum	Rural	6.5	52,900	344
Central	Gezira	Urban	6.5	51,200	333
	Gezira	Rural	6.5	333,500	2187
	Blue Nile	Urban	6.5	46,300	301
	Blue Nile	Rural	6.5	114,900	747
	White Nile	Urban	6.5	43,100	280
	White Nile	Rural	6.5	140,800	915
Southern	Upper Nile	Urban	7.5	13,300	100
	Upper Nile	Rural	7.5	101,700	763
	Jonglei	Urban	7.5	1,900	14
	Jonglei	Rural	7.5	60,100	451
	El Buheyrat	Urban	7.5	12,100	91
	El Buheyrat	Rural	7.5	69,500	521
	E. Equatoria	Urban	7.5	42,700	320
	E. Equatoria	Rural	7.5	78,500	589
	W. Equatoria	Urban	7.5	21,600	162
	W. Equatoria	Rural	7.5	37,600	282
	Bahr El Ghazal	Urban	7.5	22,000	165
	Bahr El Ghazal	Rural	7.5	94,000	705
Kordofan	N. Kordofan	Urban	6.0	38,500	231
	N. Kordofan	Rural	6.0	185,300	1112
	S. Kordofan	Urban	6.0	31,600	188
	S. Kordofan	Rural	6.0	151,800	911
Darfur	N. Darfur	Urban	6.0	27,200	163
	N. Darfur	Rural	6.0	162,800	977
	S. Darfur	Urban	6.0	29,700	178
	S. Darfur	Rural	6.0	217,000	1302
TOTAL			6.6	2,840,600	18,680

1 NEA estimates
2 Dept. of Statistics
3 Breakdown estimates from Mahmoud Khidder

TABLE II-2

TOTAL ENERGY CONSUMPTION 1980[1]
000 TOE

Sector	Hydro-Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Total
Industry	--	--	0.8	0.9	43.5	6.4	100.1	95.9	--	94.5	--	342.1
Transport	--	207.0	--	46.6	296.2	--	21.0	--	--	--	--	570.6
Agriculture	--	--	--	--	94.5	Small	--	--	--	--	--	94.5
Commercial Government Services	--	--	Small	--	9.2	--	--	83.9	87.1	--	--	180.2
Construction Oil Exploration	--	--	--	Small	34.3	--	--	--	--	--	--	34.2
Households	--	--	4.7	17.5	32.1	--	--	3,366.9	1,763.3	402.6	8.5	5,596.2
PEWC Electricity Generation	63.5	--	--	--	21.2	14.4	42.5	--	--	--	--	141.6
Total	63.5	207.0	5.5	65.0	531.0	20.8	163.6	3,546.7	1,850.4	497.1	8.5	6,959.4

1 TOE = 41.8×10^9 Joules

[1] Totals may not add due to rounding. Excludes petroleum imports from Kenya.

TABLE II-3

TOTAL ENERGY CONSUMPTION 1980 - UNITS AS NOTED[1]

Sector	Hydro-Power	Benzine/Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass [2]	Vegetable Oil
Industry	--	--	.75	.9	41.8	6.3	104.3	223	--	472.5	--
Transport[3]	--	197.1	--	44.6	284.8	--	21.9	--	--	--	--
Agriculture	--	--	--	--	90.9	Small	--	--	--	--	--
Commercial Govt' Service	--	--	Small	--	8.8	--	--	259	136	--	--
Construction and Oil Exploration	--	--	--	Small	33.0	--	--	--	--	--	--
Households	--	--	4.27	16.8	30.9	--	--	7,830	2,449	988-2039	5-12
PEWC Electricity Generation	737.8	--	--	--	20.4	14.1	44.3	--	--	--	--
TOTAL	737.8	197.1	5.02	62.3	510.6	20.4	170.5	8,312	2,585	1,460.5 - 2,511.5	5-12

[1] All unites in 000 tonnes except hydropower (Gwh).

[2] Bagasse, groundnut shells, crop residues and animal wastes. Due to large uncertainties, household consumption expresse as a range.

[3] Includes all transport.

TABLE II-4

PEWC ELECTRICITY SALES 1980 - GWH

Region / Sector	Households	Government[1] +Commercial	Heavy Industry	Agriculture[2]	Services[3]	Total
Eastern	20.0	11.3	8.5	4.6	4.1	48.5
Northern	11.3	5.6	.4	1.8	3.5	22.6
Khartoum	190.3	35.8	114.5	15.3	19.1	375.0
Central	30.3	20.2	118.4	57.2	4.1	230.2
Southern	2.9	.2	--	--	1.4	4.5
Kordofan	4.0	1.5	--	--	.7	6.2
Darfur	2.7	1.1	.7	--	1.3	5.8
Total	261.5	75.7	242.5	78.9	34.2	692.8

1 Includes 21.6 Gwh of large customers from industrial tariff plus small industries.

2 Includes 54.4 Gwh of large customers from industrial tariff; sugar included within industrial sector.

3 Street lighting, water pumping and utility use.

Source: PEWC and NEA estimates

TABLE II-5

PETROLEUM PRODUCTS CONSUMPTION, 1970 vs 1980

(TOE)

	1970	1980	% Increase
1. LPG	--	5,550	--
2. Benzene and Avgas	100,823	206,955	105%
3. Kerosene and Jet	58,285	64,792	11%
4. Gasoil	282,213	531,024	88%
5. Diesel	27,927	20,815	-25%
6. Furnace Oil	199,392	163,647	-18%
TOTAL	668,640	992,783	48.5%

TABLE II-6

GASOIL CONSUMPTION 1980

Sector/End Use		Tonnes
(1) Agriculture		90,900
Irrigation Pumping	29,300	
Agricultural Operations[2]	57,900	
Canal Maintenance	3,700	
(2) Transport[1]		284,800
Sudan Railways	26,600	
River Transport Corp.	2,300	
Lorries and Medium Trucks	176,200	
Heavy Trucks	35,200	
Buses	41,800	
Pipeline	2,700	
Diesel Autos	Small	
(3) Industry		41,800
Generators	24,400	
Boilers	small	
Bakeries	4,200	
Stationary Engines	1,900	
Sugar-Agricultural Operations[3]	11,300	
(4) Commercial, Gov't', Services		8,800
Water Pumping	8,000	
Generators	800	
(5) Construction & Oil Exploration		33,000
(6) Households		30,900
Generators[4]	4,500	
Lighting & Cooking	26,400	
(7) PEWC		20,400
TOTAL		510,600

1) Includes gasoil consumption of all goods or passenger moving vehicles including those owned by factories, schemes, government, etc.
2) Includes all operations from land preparation through harvesting and threshing.
3) Irrigation pumping uses electricity.
4) Includes all cooperatives and other rural generation.

Source: NEA estimates

Similarly, 1980 electric power consumption represents a constrained demand, with conscious power curtailments ("load shedding") and unscheduled blackouts as a regular occurrence. One measure of the PEWC's inability to meet power demands is the growth of self-generation of electricity (excluding the sugar industry, which has long generated power from bagasse) from virtually nothing in 1970 to over 110 MW of installed capacity (equivalent to over 40% of the PEWC's total installed capacity) by 1982. 80% of this self-generating capacity is in the industrial sector. Virtually all of this generation capacity, which will have to be used increasingly over the next 2-3 years, depends upon gasoil. This representing further competition with other uses of this fuel.

III. ENERGY CONSUMPTION SECTORS

1. HOUSEHOLDS

Tables III-1 and III-2 summarize energy consumption in the household sector for all regions, fuel types (in TOE), and physical units respecitvely. The rural population, which represents over 75% of the total population, consumes 78% of total energy, most of which is traditional fuels (firewood, charcoal, crop residues and animal wastes) used almost entirely for cooking. The 25% of the population that is urban, while consuming only 22% of the energy indicated in Table III-1, uses energy much more efficiently, and obtains a much higher value of work out of the energy products it consumes, particularly electricity and petroleum products.

a. Biomass Resources

Consumption per urban and rual household of firewood, charcoal, crop residues and animal wastes is estimated on the basis of several surveys conducted by NEA and Statistics Department enumerators during the course of the National Energy Assessment. Surveys conducted earlier by other individuals and organizations were used when appropriate. Estimates of yearly average household consumption of each biomass resource are shown in Table III-3. Table III-3 indicates areas directly surveyed by NEA and Statistics Department enumerators (or by other reliable sources) and it provides estimates of consumption in areas with similar socio-economic and/or ecological characteristics which were not surveyed. These estimates are based on the following assumptions:

Khartoum:

Urban, Rural: Based on the extensive work of Mohammed El-Amin Mukhtar, 1978-1980.

Gezira:

Urban: Based on NEA Khartoum urban and Gezira rural survey results.
Rural: Based on NEA survey results.

Blue Nile:

Urban: Charcoal based on Khartoum survey results, wood based on NEA Kassala urban surveys.
Rural: Based on NEA rural surveys of Kassala, Gezira and southern Blue Nile Provinces, taking into consideration the distribution of population within the province.

White Nile:

Urban, Rural: Based on NEA Gezira and Kordofan survey results, assuming charcoal enters White Nile from the South and West. Survey results of ANwar Sheikh El Din show lower consumption in the province than NEA estimates.

TABLE III-1

HOUSEHOLD ENERGY CONSUMPTION 1980

TOE

Fuel / Region	Wood	Charcoal	Crop[1] Residues	Animal[1] Wastes	LPG[2]	Kerosene	Gasoil	Vegetable Oil	Purchased Electricity	Total
Eastern	265,740	167,760	15,680	8,750	485	6,032	4,160	--	1,722.4	470,329.4
Northern	77,830	91,440	13,920	8,750	42	1,144	2,392	--	973.2	196,491.2
Khartoum	75,250	172,800	Small	Small	4,155	4,680	2,600	--	16,388.4	275,873.4
Central	647,150	425,520	67,200	87,200	35	3,224	8,736	8,500	2,609.4	250,174.4
Southern	1,223,780	261,360	14,080	187,250	--	--	1,352	--	249.8	1,688,071.8
Kordofan	505,250	316,800	small	small	--	1,560	4,784	--	344.5	828,738.5
Darfur	571,900	327,600	small	small	--	882	3,432	--	232.5	904,046.5
Undistributed	--	--	--	--	--	--	4,680	--	--	4,680.0
Sub-Total Urban	495,790	668,160	2,000	6,000	4,717	17,472	32,126	8,500	22,520.2	1,263,286.0
Sub-Total Rural	2,871,110	1095,120	108,880	285,950	--	--	--	--	--	4,360,860.0
GROSS TOTAL	3,366,900	1763,280	110,880	291,950	4,717	17,522	32,126	8,500	22,520.2	5,618,405.2

[1] Average of range appearing in Table III-3
[2] Assumes 67% and 33% of industrial LPG is consumed in Khartoum and Port Sudan, respectively.

TABLE III-2

HOUSEHOLD ENERGY CONSUMPTION 1980
(Units As Shown)

Region \ Fuel	Wood 000 Tons	Charcoal 000 Tons	Crop Residues 000 Tons	Animal Wastes 000 Tons	LPG Tons	Kerosene Tons	Gasoil[2] Tons	Vegetable Oil Tons	Purchased Electricity Gwh
Eastern	618	233	40-58	26-44	437	5,800	4,000	--	20.0
Northern	181	127	14-73	11-59	38	1,100	2,300	--	11.3
Khartoum	175	240	Small	Small	3743	4,500	2,500	--	190.3
Central	1,505	591	210	348	32	3,100	8,400	5,000-12,000	30.3
Southern	2,846	363	18-70	321-1,177	--	--	1,300[1]	--	2.9
Kordofan	1,175	440	Small	Small	--	1,500	4,600	--	4.0
Darfur	1,330	455	Small	Small	--	800	3,300	--	2.7
Undistributed	--	--	--	--	--	--	4,500[2]	--	--
Subtotal Urban	1,153	928	12-38	10-38	4250	16,800	30,900	5,000-12,000	261.5
Subtotal Rural	6,677	1,521	270-373	696-1590	--				
Total Sudan	7,830	2,449	282-411	706-1628	4250	16,800	30,900	5,000-12,000	261.5

Source: PEWC, GPC and NEA Surveys

[1] Excluding petroleum products imported from Kenya.

[2] Gasoil consumed for lighting, cooking and in generators belonging to households and rural cooperatives.

Generated Electricity = 2.4 Gwh Urban
10.9 Gwh Rural (includes cooperatives)
13.3

ESTIMATE OF ANNUAL BIOMASS CONSUMPTION BY HOUSEHOLDS

PROVINCE	URBAN RURAL	PERSONS PER HOUSEHOLD	NUMBER OF HOUSEHOLDS	WOOD LBS/HH	CHARCOAL LBS/HH	CROP RESIDUES LBS/HH	ANIMAL WASTES LBS/HH	WOOD 000 TONS	CHARCOAL 000 TONS	CROP RESIDUES 000 TONS	ANIMAL WASTES 000 TONS
Red Sea	Urban	7.0	32,900	1,200[e]	2,000[e]	--	--	18	30	--	--
Red Sea	Rural	7.0	50,900	2,800[e]	1,500[e]	200-1000[e]	200-1000[e]	65	35	5-23	5-23
Kassala	Urban	7.0	60,000	4,000[s]	2,300[s-]	Small	---	109	63	Small	--
Kassala	Rural	7.0	153,700	6,100[s]	1,500[s-]	500[e]	300[s]	426	105	35	21
Northern	Urban	6.0	8,500	1,500[e]	1,800[e]	Small	Small	6	7	Small	Small
Northern	Rural	5.0	58,800	2,200[e]	1,600[e]	200-1000[e]	200-1000[e]	59	43	5-27	5-27
Nile	Urban	6.0	30,300	1,900[s]	1,900[s]	200-1000[e]	Small	26	26	3-14	Small
Nile	Rural	6.0	70,700	2,800[s-]	1,600[s-]	200-1000[s+]	200-1000[s+]	90	51	6-32	6-32
Khartoum	Urban	6.5	193,200	1,500[s]	2,300[s]	---	---	[illegible]	202	---	--
Khartoum	Rural	6.5	52,900	1,800[s]	1,600[s]	Small	Small	[illegible]	38	Small	Small
Gezira	Urban	6.5	51,200	2,200[e]	2,300[e]	Small	---	94	54	---	--
Gezira	Rural	6.5	333,500	2,900[s]	1,600[s]	1,100[s]	2,100[s]	440	243	167	318
Blue Nile	Urban	6.5	46,300	4,100[e]	2,300[e]	Small	--	86	48	Small	--
Blue Nile	Rural	6.5	114,900	11,500[s-]	1,200[s+]	200[e]	200[e]	501	63	11	11
White Nile	Urban	6.5	43,100	2,800[e]	2,800[e]	---	---	55	55	---	--
White Nile	Rural	6.5	140,800	4,200[e]	2,000[e]	500[e]	300[e]	269	128	32	19
Upper Nile	Urban	7.5	13,300	5,000[e]	2,400[e]	Small	Small	30	15	Small	Small
Upper Nile	Rural	7.5	101,700	8,000[e]	1,000[e]	200-1000[e]	1000-5000[e]	370	46	9-46	46-231
Jonglei	Urban	7.5	1,900	3,500[e]	500[e]	Small	5000-10000[e]	3	Small	Small	4-9
Jonglei	Rural	7.5	60,100	5,000[e]	---	Small	5000-10000[e]	137	---	Small	137-273
El Buheyrat	Urban	7.5	12,100	5,000[e]	2,400[e]	Small	Small	2828	13	Small	Small
El Buheyrat	Rural	7.5	69,500	6,000[e]	1,000[e]	Small	1000-5000[e]	190	32	Small	32-158
E. Equatoria	Urban	7.5	42,700	9,900[s]	3,900[s]	200-1000[s-]	200-1000[e]	192	76	4-19	4-19
E. Equatoria	Rural	7.5	78,500	20,000[s-]	800[s]	---	1000-5000[e]	714	29	---	36-178
W. Equatoria	Urban	7.5	21,600	12,100[s]	4,800[s]	---	200-1000[e]	119	47	---	2-10
W. Equatoria	Rural	7.5	37,600	20,000[s+]	800[s]	---	1000-5000[e]	342	14	---	17-85
Bahr El Ghazal	Urban	7.5	22,000	8,000[s-]	4,800[s-]	500[s+]	Small	90	48	5	Small
Bahr El Ghazal	Rural	7.5	94,000	15,000[e]	1,000[e]	---	1000-5000[e]	641	43	---	43-214
N. Kordofan	Urban	6.0	38,500	3,500[e]	4,000[e]	---	---	61	70	---	---
N. Kordofan	Rural	6.0	185,300	6,000[e]	2,000[e]	---	---	505	168	---	---
S. Kordofan	Urban	6.0	31,600	4,000[s+]	4,500[s-]	---	---	57	64	---	---
S. Kordofan	Rural	6.0	151,800	8,000[s+]	2,000[s+]	---	---	552	138	---	---
N. Darfur	Urban	6.0	27,200	3,500[e]	4,000[e]	---	---	43	49	---	---
N. Darfur	Rural	6.0	162,800	6,000[e]	2,000[e]	---	---	444	148	---	---
S. Darfur	Urban	6.0	29,700	4,000[e]	4,500[e]	---	---	54	61	---	---
S. Darfur	Rural	6.0	217,000	8,000[e]	2,000[e]	---	---	789	197	---	---

[s] = Surveyed quantity [s+] = Higher than surveyed quantity
[s-] = Lower than surveyed quantity [e] = estimate based on results of surveys in other areas.

Source: Surveys by MEA, M. Mukhtar T. Hammer and A. Sheikh El Din.

Upper Nile:

Urban: Wood assumed to be used more and charcoal somewhat less relative to White Nile consumption.
Rural: Wood assumed to be readily available, similar to S. Kordofan. Charcoal use assumed to be small, due to transport difficulty and availability of alternative fuels. Crop and animal waste estimates based on assumed availability and NEA surveys of Gezira and Juba.

Jonglei:

Urban, Rural: Based on Upper Nile estimates and Juba survey, but wood and charcoal are assumed to be scarce and animal wastes are readily available and widely used. There is a large uncertainty in this case, as this ecological zone has not been surveyed by the NEA. However, Jonglei Canal Project surveys of area bear out NEA estimates.

El Buheyrat:

Urban, Rural: Estimates based on NEA Wau survey as well as Upper Nile and Jonglei estimates. Consumption of wood and charcoal is felt to be higher than in Jonglei, as population is more concentrated and located in drier, more forested areas.

E. Equatoria:

Urban: Based on NEA survey results, except for crop residues, which appear to be too high and have been reduced after discussions.
Rural: Wood consumption assumed lower than NEA surveys indicate, as survey locations are assumed to be richer in forests than average rural areas. Charcoal is obtained from NEA survey results.

W. Equatoria:

Urban: Based on NEA surveys.
Rural: Higher than NEA survey results as survey locations were probably not representative of rural Equatoria. Animal wastes are based on Gezira results because animal wastes were not included in the NEA Southern Region survey.

Bahr El-Ghazal:

Urban: Taken as somewhat lower than survey results (from Wau), as location and income groups surveyed are assumed to be nonrepresentative of the average in urban centers of the province.
Rural: Consumption is assumed to be somewhat lower than revealed in surveys of Mariedi and Yei.

N. Kordofan:

Urban, Rural: Based on NEA surveys of S. Kordofan, but consumption is judged to be somewhat lower. Turi Hammer's[3] survey results show consumption to be approximately double NEA survey findings.

S. Kordofan:

Urban: Based on NEA surveys. Wood consumption is assumed to be higher than revealed in NEA surveys and charcoal somewhat less, as survey locations are judged to be not totally representative of the average.

Rural: Estimates are based on NEA surveys in Wau, Juba, Blue Nile.

N. Darfur:

Urban, Rural: Assumed to be the same as N. Kordofan.

S. Darfur:

Urban, Rural: Assumed to be the same as S. Kordofan, but could be higher given extensive forests in the province.

Red Sea:

Urban: Based on Mohammed El-Amin Mukhtar survey in Khartoum, NEA surveys in Kassala and Nile Provinces. Charcoal figure is low because LPG and Kerosene are also used for cooking by a significant fraction of households.
Rural: Charcoal based on NEA Kassala results. Wood based on NEA Nile Province survey. Crop residues and animal wastes are based on Nile Province survey.

Kassala:

Urban, Rural: Wood taken as determined through surveys. Charcoal is decreased as survey locations are thought to be more affluent than average, urban and rural areas.

Northern:

Urban, Rural: Based on NEA survey results in Nile, Khartoum Provinces. Though wood and charcoal are scarce or must be transported great distances, consumption is assumed to be significant as people are relatively affluent.

Nile:

Urban: From NEA survey results.
Rural: Wood and charcoal based on Khartoum survey, as NEA Nile Province rural survey results seem high. Animal and Crop wastes based on surveys, Gezira and Kassala results.

Additional information on charcoal and firewood consumption is given in Table III-4. Charcoal consumption is shown on the basis of m^3 per capita of wood equivalent obtained from Table III-3 and converted from tonnes at the rate of $18m^3$ of growing stock per tonne of charcoal. Studies conducted during the 1950's (Jackson, 1960; Saini, 1962) estimated a conversion ratio of some 2.70-2.90m^3 of firewood (growing stock) per metric ton of stacked firewood and a conversion efficiency from firewood to charcoal of some 5.5 to 1. Mohammed El-Amin Mukhtar and Forestry Administration experts estimate that today the conversion ratio from 3.0-3.1m^3 of growing stock yields one metric ton of stacked firewood and that 6.0 tons of firewood are necessary to yield 1 ton of charcoal, or $18m^3$ growing stock to equal one M.T. of charcoal. This results from the effects of heavy forest degradation and use in major areas of charcoal production whereby increasingly inferior species with lower yields, less density and lower specific gravity are being used for both firewood and charcoal production. Tables III-5 and III-6 show the estimates of fuelwood consumption made earlier by Jackson (1960) and Saini (1962).

The household surveys undertaken by the NEA typically consisted of 60 interviews per village. Areas surveyed were carefully selected beforehand to ensure representation of general income levels, ecological zones, economic activities and so on, to enable the results to be extrapolated on a wider basis to other areas in Sudan. Each sample was selected by the survey team upon arrival one day prior to the actual interviews (except in Gezira province, where an existing sample, constructed by the University of Gezira, was used). The interview process was complemented by actually weighing typical daily fuel requirements at each household using a spring balance. The amounts and types of fuels typically purchased or gathered on a regular basis were indicated by the interview subject. A summary of the survey results, listed by village, is presented in Table III-7. Province, date of interview, description of area (rural or urban) and annual fuel usage per household are indicated. Exhibit 1 contains copies of the survey questionnares in Arabic and English which were used by enumerators. The complete results of the survey will be thoroughly detailed in the Household Sector Report (NEA, 1983).

b. Kerosene and Gasoil

Kerosene consumption in the Sudan is strictly determined by the amount made available through government imports and Port Sudan refinery output. For various reasons, outlined in the Executive Summary Report, kerosene sales have dropped dramatically from over 67,000 tonnes in 1972 to 10,433 tonnes today. The drop in consumption on a per capita basis is shown in Table III-8. Furthermore, supplies are easily available only in the Red Sea Province (where the refinery and port are located). The NEA surveys revealed that large amounts of gasoil and vegetable oils are being substituted for kerosene because of the latter's inavailability and, consequently, high price.

An in-depth analysis has been undertaken by NEA and Project staff, based upon time series kerosene supply data (dating from the 1960's) and NEA survey results, in an effort to gauge the extent of real demand for kerosene. This, in turn, is compared to the actual satisfied demand or consumption in 1980. The latter is the amount that has been incorporated in the energy balances.

TABLE III-4

TOTAL HOUSEHOLD FUEL WOOD CONSUMPTION BY PROVINCES AND SECTORS
(in m^3 of growing stock equivalent)

Province	(1980) Population (000)	Charcoal				Fuelwood				Total Fuelwood			
		Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)	Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)	Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)
Khartoum	1600	3636	684	4320	2.7	396	129	525	0.33	4032	813	4845	3.03
Gezira	2520	972	4374	5346	2.12	162	1320	1482	0.59	1134	5694	6828	2.71
Blue Nile	1048	864	1134	1998	1.91	258	1803	2061	1.97	1122	2937	4059	3.87
White Nile	1195	990	2304	3294	2.76	165	807	972	0.81	1155	3111	4266	3.57
Kassala	1496	1134	1890	3024	2.02	327	1278	1605	1.07	1461	3168	4629	3.09
Nile	606	468	918	1386	2.29	78	270	348	0.57	546	1188	1734	2.86
S. Kordofan	1099	1152	2484	3636	3.31	171	1656	1827	1.66	1323	4140	5463	4.97
N. Kordofan	1343	1260	3024	4684	3.19	183	1515	1698	1.26	1443	4539	5982	4.45
S. Dar Fur	1480	1098	3546	4644	3.14	162	2367	2529	1.71	1260	5913	7173	4.85
N. Dar Fur	1140	882	2664	3546	3.11	129	1332	1461	1.28	1011	3996	5007	4.39
Red Sea	586	540	630	1170	2.0	54	195	249	0.42	594	825	1419	2.42
Northern	404	126	774	900	2.23	18	177	195	0.48	144	951	1095	2.71
E. Equatoria	909	1368	552	1890	2.08	576	2142	2718	2.99	1944	2664	4608	5.07
W. Equatoria	444	846	252	1098	2.47	357	1026	1383	3.11	1203	1278	2481	5.59
Bahr El Ghazal	870	864	774	1638	1.88	240	1923	2163	2.49	1104	2697	3801	4.37
Upper Nile	863	270	828	1098	1.27	90	1110	1200	1.39	360	1938	2298	2.66
Jonglei	465	-	-	-	-	9	411	420	.09	9	411	420	0.9
El Buhyrat	612	234	576	810	1.32	84	570	654	1.07	318	1146	1464	2.39
TOTAL	18,680	16,704	27,408	44,482	2.36	3,459	20,031	23,490	1.26	20,163	47,409	67,572	3.62

Source: NEA.

TABLE III-5

TOTAL HOUSEHOLD FUELWOOD CONSUMPTION BY PROVINCES AND SECTORS: 1955/56

(in m^3 Growing Stock Wood Equivalent)

Province	(1955-56) Population (000)	Charcoal				Fuelwood				Total Fuelwood			
		Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)	Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)	Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)
Khartoum	505			783	1.55			290	0.57			1073	2.12
Gezira	854			2088	2.44			649	0.76			2737	3.2
Blue Nile	593			148	0.25			1141	1.92			1289	2.17
White Nile	623			965	1.55			455	0.73			1420	2.28
Kassala	784			1198	1.53			581	0.74			1779	2.27
Nile	491			182	0.37			295	0.6			477	0.97
S. Kordofan	1084			-	-			1273	1.17			1273	1.17
N. Kordofan	679			336	0.49			665	0.98			1001	1.47
S. Darfur	720			53	0.09			2157	3.0			2157	3.0
N. Darfur	608			279	1.78			1387	2.28			1440	2.37
Red Sea	157			68	0.18			118	0.75			397	2.53
Northern	380			-	-			151	0.4			219	0.58
E. Equatoria	589			-	-			748	1.27			748	1.27
W. Equatoria	315			-	-			621	1.97			621	1.97
Bahr El-Ghazal	991			-	-			1984	2.0			1984	2.0
Upper Nile	301			-	-			628	2.09			628	2.09
Jonglei	184			-	-			93	0.51			93	0.51
El-Buhyrat	405			-	-			604	1.49			604	1.49
TOTAL	10,263			6,100	0.59			13,840	1.35			19,940	1.94

Source: J. K. Jackson from 1955/56 National Census in "Report to the Government of Sudan on Forest Management," FAO, Rome, 1960.

TABLE III-6

TOTAL HOUSEHOLD FUELWOOD CONSUMPTION BY PROVINCES AND SECTORS: 1962

(in m^3 Growing Stock Wood Equivalent)

Province	(1955-56) Population (000)	Charcoal				Fuelwood				Total Fuelwood			
		Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)	Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)	Urban (000m3)	Rural (000m3)	Total (000m3)	Per Capita (m3)
Region A:	2,319	2,176	3,978	6,154	2.65	378	3,335	3,713	1.6	2,554	7,313	9,867	4.25
Kassala Khartoum Northern													
Region B:	2,070	634	4,675	5,309	2.56	143	3,151	3,294	1.59	777	7,826	8,603	4.15
Blue Nile													
Region C:	3,091	612	18	630	.02	173	5,077	5,250	1.7	785	5,095	5,880	1.9
Kordofan Darfur													
Region D:	2,783	335	40	375	0.13	56	4,611	4,667	1.68	391	4,651	5,042	1.81
Upper Nile Equatoria Bahr El-Ghazal													
TOTAL	10,263	3,757	8,711	12,468	1.21	750	16,174	16,924	1.65	4,507	24,885	29,392	2.86

Source: T.S. Saini, "Present Wood Consumption and Future Requirements." FAO, Rome, 1962.

TABLE III-7

National Energy Administration - Household Energy Survey Preliminary Results
(Annual Energy Consumption per Household)

(Page 1)

	Province	Village	Urban Rural	Survey Date	Households Surveyed	Wood Kg.	Charcoal Kg.	Crop/Kg. Residues	Animal Waste Kg.	Kerosene Gallons	Gasoil Gallons	Vegetable Oil Gallons
	Gezira											
1.	"	-Wad Kray	Rural	22-23-24/3/82	94	937.3	749.9	539.1	475.0	1.9	9.6	18.4
2.	"	-Wad Sulliman	"	21/3/82	51	1931.8	1242.7	647.7	473.6	3.3	1.9	11.5
		-Kambo Tanta	"	2/3/82	18	1990.0	154.1	106.4	1578.6	--	--	--
3.	"	-El Taimab	"	24/3/82	72	398.6	759.5	794.1	1369.5	--	2.8	--
	Kassala											
4.	"	Kassala-Mirghania A/	Urban	8/4/82	30	2175.9	1585.4	--	--	12.0	7.3	--
5.	"	Kassala-Mirghania B/	"	8/4/82	30	1105.9	1139.1	--	--	20.3	1.6	--
6.	"	Kassala-Banat West	"	6/4/82	60	2167.7	1053.2	18.2	--	9.9	12.0	--
7.	"	Kassala-Kurmutta	"	4/4/82	60	2474.5	739.5	291.4	--	8.9	9.4	--
8.	"	New Halfa-El Gafala	Rural	1/4/82	60	3300.0	683.2	51.4	--	7.9	13.6	--
9.	"	New Halfa-Um Araniba/A	"	30/3/82	30	3520.0	1055.9	40.0	--	2.6	10.4	--
10.	"	New Halfa-Um Araniba/B	"	30/3/82	30	2848.6	901.8	146.4	522.7	6.9	9.4	--
11.	"	New Halfa-Sura West/A	"	31/3/82	30	2885.0	870.5	325.5	--	--	9.4	--
12.	"	New Halfa-Sura West/B	"	31/3/82	30	2024.5	1132.3	667.3	--	6.3	21.4	--
13.	"	Gedarif-Rowena	"	28/3/82	62	2499.5	656.4	139.1	292.7	5.3	15.1	--
	Blue Nile											
15.	"	Ilyias	"	3/82	26	7351.4	172.5	--	--	--	12.3	--
16.	"	AbuShenina	"	3/82	32	9665.9	134.4	--	--	--	12.5	--
17.	"	Shaera	"	3/82	31	10993.1	--	--	--	--	--	--

1. Have Electricity Hook-up

TABLE III-7 (continued)

National Energy Administration - Household Energy Survey Preliminary Results
(Annual Energy Consumption per Household)

(Page 2)

	Province	Village	Urban Rural	Survey Date	Households Surveyed	Wood Kg.	Charcoal Kg.	Crop/Kg. Residues	Animal Waste Kg.	Kerosene Gallons	Gasoil Gallons	Vegetable Oil Gallons
18.	Blue Nile	El Gzumaii	Rural	3/82	23	12159.0	199.1	--	--	--	11.5	--
19.	"	Kharen Kharen	"	3/82	34	16579.3	--	--	--	--	19.1	--
20.	"	Esseil	"	3/82	15	10629.8	652.6	--	--	--	7.6	--
21.	Eastern Equatoria	Juba/A & B	Urban	12/4/82	17	10571.8	1068.6	1550.9	--	4.7	2.6	--
22.	"	Malakal 1/ No. 3	"	11/4/82	25	676.8	1408.6	763.6	--	18.6	0.8	--
23.	"	(UMO) Karpeto	Rural	29/3/82	26	15247.3	--	--	--	0.2	0.2	--
24.	Bahr El Ghazal	Wau 1/	Urban	23/4/82	37	3963.2	3969.5	90.6	--	7.3	4.2	--
25.	Eastern Equatoria	Loa	Rural	2/4/82	9	4910.9	728.2	--	--	--	08.8	--
26.	Eastern Equatoria	Nimule	Urban	2/4/82	51	6653.2	816.2	--	--	01.1	24.9	--
27.	"	Juba/Gau 1/- Aba Musalo	"	11/4/82	14	1518.6	1154.4	670.5	--	13.2	02.4	--
28.	"	Juba 1/	"	11/4/82	11	10595.9	1072.7	878.5	--	06.8	02.6	--

TABLE III-7 (continued)

National Energy Administration - Household Energy Survey Preliminary Results
(Annual Energy Consumption per Household)

(Page 3)

	Province	Village	Urban Rural	Survey Date	Households Surveyed	Wood Kg.	Charcoal Kg.	Crop/Kg. Residues	Animal Waste Kg.	Kerosene Gallons	Gasoil Gallons	Vegetable Oil Gallons
29.	"	Kattor	"	11/4/82	12	5252.7	1250.0	954.5	--	18.2	03.7	--
30.	"	Monkey	"	13/4/82	5	3318.2	581.8	116.4	--	06.4	00.4	--
31.	Western Equatoria	Mariedi	"	15/4/82	25	3854.5	2397.3	--	--	32.2	04.4	--
32.	"	Yambio 1/	"	17/4/82	25	7183.2	1933.6	--	--	02.6	02.1	--
33.	"	Kosti Malakia	"	4/4/82	13	7400.0	1435.0	740.9	--	09.9	02.7	--
34.	Western Equatoria	Yei 1/	"	20/4/82	25	3606.4	2592.3	--	--	45.1	02.0	--
35.	Nile Province	Shendi-Prim.1 Girls	"	Oct. 81	122	670.9	960.0	--	--	24.3	6.1	--
36.	"	Shendi-Prim.1 Girls	"	"	160	709.1	790.9	--	--	37.7	4.9	--
37.	"	Shendi/1-Sec. Girls	"	"	33	507.3	927.3	--	--	21.3	8.5	--
38.	"	Atbara-Prim. 1 Girls	"	"	163	163.6	981.8	--	--	35.3	--	--
39.	"	Atbara-Sec. 1 Girls	"	"	87	1145.5	709.1	--	--	26.8	--	--

TABLE III-7 (continued)

National Energy Administration - Household Energy Survey Preliminary Results
(Annual Energy Consumption per Household)

(Page 4)

	Province	Village	Urban Rural	Survey Date	Households Surveyed	Wood Kg.	Charcoal Kg.	Crop/Kg. Residues	Animal Waste Kg.	Kerosene Gallons	Gasoil Gallons	Vegetable Oil Gallons
40.	"	Atbara-Sec. 1 Boys	"	Oct. 81	97	540.0	818.2	--	--	34.1	3.0	--
41.	"	Damer-Sec. 1 Girls	"	"	71	949.1	731.0	--	--	16.5	5.1	--
42.	"	Shendi Sec. Girls	Rural	"	143	1745.5	872.7	--	--	26.8	2.4	--
43.	"	Shendi Sec. Boys	"	"	84	2312.7	1052.7	--	--	30.4	--	--
44.	"	El Hafyan Village	"	"	42	3163.6	103.6	--	--	20.7	11.7	--
45.	"	Damer Prim. Tech. Col.	"	"	70	2530.9	1080.0	--	--	35.6	--	--
46.	Kordofan	El Dalanj	Urban	Jan. 82	*	2545.8	2503.0	--	--	--	--	--
47.	"	"	"	"	*	1830.5	1721.6	--	--	--	--	--
48.	"	"	"	"	*	552.5	3041.7	--	--	--	--	--
49.	"	"	"	"	*	772.6	2231.5	--	--	--	--	--
50.	"	"	"	"	*	2212.0	1662.0	--	--	--	--	--
51.	"	El Shihata	Rural	June 82	66	1515.3	826.1	--	--	10.9	0.7	--

For samples 1-34 detailed questionnaires were administered by trained enumerators and daily fuel consumption was determine by weighing with spring balances. For samples 46-51 NEA and Forestry students administered a simpler questionaire to households identified through on-site random sampling and did not weigh fuels. For samples 35-45 the questions used for samples 45-51 was administered to primary and secondary school students, who filled it out with help from their parents.

* Total Households Surveyed = 192

TABLE III-8

KEROSENE CONSUMPTION IN THE SUDAN

Year	Population (1) Urban (000)	Rural (000)	Total (000)	Percentage Increase (%)	Total Consumption (000 I.G.)	Kerosene Consumption (2) (Imperial Gallons) Per Capital Consumption I.G./yr/cap	Percentage(%) Change P.C. Consumption
1972	2527	12,253	14,780	--	18.610	1.26	--
1973	2763	12,467	15,230	2.96	14,285	0.94	-25.5
1974	2995	12,685	15,681	"	8,999	0.57	-39.4
1975	3244	12,896	16,145	"	10,021	0.62	+ 8.8
1976	3507	13,113	16,623	"	8,633	0.52	-16.1
1977	3764	13,346	17,115	"	8,886	0.52	0
1978	4053	13,567	17,621	"	6,672	0.38	-26.9
1979	4354	13,786	18,143	"	4,859	0.27	-28.9
1980	4665	14,015	18,600	"	4,977	0.27	0

(1) Breakdown urban (vs) rural, total population, and percentage increase derived from 1973 and 1980 demographic estimates made by Mahmaud Khider, Dept. of Statistics.

(2) Source: Dr. Abdel Rahim. "Towards a New Kerosene Consumption Policy", GPC, 1982.

TABLE III-9

HOUSEHOLD KEROSENE AND GASOIL CONSUMPTION 1980

Province	Kerosene Supply (Tons) Now	Kerosene Supply (Tons) Highest	Maximum Demand Gals./H.H.	Est. Real Demand Gals./H.H.	Est. Satisfied Demand/household Kerosene	Est. Satisfied Demand/household Gasoil	Est. Present Distrib. (Tons) Kerosene	Est. Present Distrib. (Tons) Gasoil	Est. Total Demand Tons	NEA Results Gallons/HH	Survey
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Red Sea	16,000	23,400	85	11	7.0	2.0	2,600+ 900 ind.	700	4,000	Kerosene	Gasoil
Kassala	16	5,600	8	9	3.5	3.5	3,200	3,300	8,400	--	--
Northern	60	3,125	13	14	1.0	3.0	300	800	3,500	--	--
Nile	400	5,120	15	15	2.0	4.0	800	1,500	5,300	urb 28	--
										rur 28	--
Khartoum	950	26,000	38	11	4.5	2.5	4,500	2,500	11,000	urb 7	--
										rur 9	--
Gezira	57	7,000	6	9	1.0	3.0	1,600	2,800	14,100	rur 1	rur 4
Blue Nile	140	3,085	6	9	1.0	4.0	700	2,600	5,900	--	rur 1
White Nile	54	3,325	6	9	1.0	4.0	800	2,000	6,700	--	--
Kordofan	--	4,970	4	8	1.0	3.0	1,500	4,600	12,200	urb 6-13	--
Darfur	10	2,100	2	6	.5	2.0	800	3,300	9,800	--	--
E. Equatoria	--	--	--	4	?	1.0	--	800	2,300	urb 13	urb 7
										urb 8	rur 9
W. Equatoria	--	--	--	4	--	--	--	--	1,100	urb 17	urb 3
Upper Nile				4		1.0	--	500	2,200	--	--
Bahr El Ghazal	--	--	--	4	--	--	--	--	?,200	--	--
El Buheyrat	--	--	--	4	--	--	--	--	1,500	--	--
Jonglei	--	--	--	4	--	--	--	--	800	--	--
TOTAL							17,700	25,400	91,000		

Source: GPC and NEA surveys

Table III-9 contains an analysis of kerosene demand and consumption by province, together with the current consumption of gasoil which substitutes for the kerosene in short supply. Columns (1) and (2) show kerosene sales by province as reported by GPC for 1980 and for a prior date in which sales for that particular province were at a maximum (generally 1972). It can be seen that by 1980, over 90% of all household kerosene was officially distributed inside Red Sea Province. It is clear from data gathered by NEA staff, however, that actual consumption takes place in a markedly different regional pattern through informal markets. This can be seen in columns (10) and (11) which show annual gallons of kerosene and gasoil use per household for the provinces in which NEA household surveys were conducted. The weighted average of urban and rural households in these provinces yield estimated average "satisfied" demand per household in 1980, in columns (5) and (6). For other provinces, estimates were made based on their proximity to Port Sudan and their access to the Port Sudan Khartoum highway as well as observations furnished by NEA and GPC staff members. By multiplying estimated annual consumption per household in each province by the number of households in each province, total kerosene and gasoil consumption in 1980 was obtained, as shown in columns (7) and (8). Some 17,700 tonnes of kerosene and 26,400 tonnes of gasoil were used in households (mainly for lighting) during 1980. In addition, some 6800 tonnes of gasoil were used by households, for the most part for electric self-generation. This is less than one half the estimated real demand of 91,000 tonnes as shown in column (9). This real demand is obtained from observations in years of higher supplies (generally 1972 when it was estimated that most demand was being satisfied). Column (3) shows average kerosene sales per household by province for the year with the highest sales on record. Because GPC sales by province is a poor measure of actual consumption by province, adjustments were made as shown in column (4). Red Sea and Khartoum provinces are assumed to serve as supply points for neighboring provinces. Real demand in 1980 is obtained by applying these figures to current statistics on number of households.

c. Electricity: Household electricity consumption figures have been obtained directly from NEC data on (a) the number of residential sectors in each area serviced, and (b) total sales ascribed to residential customers. Table III-10 provides a region-by-region breakdown based on this data. Household electricity consumption attributed to self-generation is relatively small compared to NEC sales and is discussed in the "self-generation" section of this Annex.

2. AGRICULTURE

Energy in the agriculture sector has been estimated from a detailed analysis of agricultural activities by area and by crop. The activities included are irrigation pumping, mechanized agricultural operation (i.e. land preparation, fertilizer application, spraying, etc.) and maintenance of irrigation canals. Excluded from the analysis is transportation of goods and persons within the agriculture sector, which has been incorporated within the transportation sector (see 4 below). It is important

TABLE III-10

ANNUAL ELECTRICITY CONSUMPTION PER RESIDENTIAL CUSTOMER

REGION	1980/1981 # Residential Meters	Consumption/Meter MWH
EASTERN	15,093	1,183
CENTRAL	75,990	392
KHARTOUM	101,022	1,854
KORDOFAN	14,509	323
DARFUR	6,709	444
NORTHERN	17,769	603
SOUTHERN	4,388	709

Source: NEC

to bear this exclusion in mind, since the energy demand statistic for the agricultural sector most frequently cited in the literature corresponds to total GPC sales of gasoil to agricultural concerns, which is about 50% higher than the gasoil demand for the agricultural sector as defined narrowly here.

Irrigation, agricultural operations and canal maintenance consumed 90,900 tonnes of gasoil and 78.9 Gwh of electricity (for electric irrigation pumps) in 1980, as shown in Table III-11. These estimates have been built up from a large number of coefficients of fuel use per activity per feddan of cultivation for various crops and schemes in the Sudan, as detailed below. In the process of assembling the energy aggregates, NEA and Project staff compiled a complete set of statistics of land under cultivation by type of cultivation (irrigated, rainfed mechanized or traditional) by region, by crop and by scheme. This information, which was prepared by Abbas Hidayat Allah, is presented in Tables III-12 to III-17. The Central and Eastern regions account for 44% and 40% respectively, of all irrigated or mechanized feddans. This calculation includes the 120,000 feddans on which sugar was presently grown in 1980. Particularly notable in Table III-12 are the large number of feddans devoted to traditional agriculture. In this analysis, no agricultural fuel consumption has been attributed to these feddans, as, by definition, fuel is not required for irrigation or agricultural operations. It has been reported, however, that particularly in Kordofan, a number of traditional cultivators are now using tractors for land preparation. Data available to estimate this fuel consumption is insufficient at present.

a. Irrigation: More than 3 million feddans under cultivation are irrigated in the Sudan, but about 75% is irrigated by gravity or flooding and requires no energy inputs. Of the remainder, 281,500 feddans are irrigated by electric pumps which obtain their electricity from commercial sources, primarily along the Blue Nile Grid. It is worthwhile to note that the gasoil equivalent of the 78.9 Gwh of electricity used in irrigation pumping amounts to some 26,500 tonnes, a magnitude similar to the direct use of gasoil used for irrigation pumping. Total Gwh used for pumping was obtained from NEC records of sales to large-scale agricultural consumers (from its tariff structure).

   Gasoil consumption for irrigation was calculated on the basis of meters of pumping head, volume of water lifted and typical technical performance parameters for gasoil pumps. Table III-18 shows average irrigation heads by scheme and crop (in meters); additional information on seasonal variations of head by scheme is given in Table III-19. The sources for this data are river gauging stations and a study by Abdel Karim Asakir, Ministry of Agriculture and Irrigation, on electrification of pumps along the Blue and White Niles.

   Pumping heads were estimated for other areas by NEA and project staff. Volume of water lifted per feddan by scheme and crop was obtained from the Nile Water Study (Gibbs, et al.) and assumptions by NEA staff and advisors indicated in Table III-20.

TABLE III-11

AGRICULTURE ENERGY CONSUMPTION 1980[1]

(Gasoil)

(Tonnes)

Regions	Irrigation[3]	Agricultural Operations	Canal Maintenance[2]	Total	Electricity (Gwh) Irrigation
Eastern	1,400	23,000	100	24,500	4.6
Northern	8,000	500	400	8,900	1.8
Khartoum	600	100	-	700	15.3
Central	14,200	29,400	3,200	46,800	57.2
Southern	300	3,300	-	3,600	-
Kordofan	2,200	1,500	-	3,700	-
Darfur	2,600	100	-	2,700	-
TOTAL	29,300	57,900	3,700	90,900	78.9

1 Sugar is included in industrial sector; gasoil used to transport crops and labor is included in transport sector.

2 Total consumption including transport estimated at 5,300 tons.

3 Using the equations: gallons of gasoil = m^3 of water x head in meters x .355 x 10^{-3}.

Source: NEA estimates based on information from Ministry of Agriculture and Irrigation, Petroleum distributing companies and NEA surveys.

TABLE III-12

FEDDANS UNDER CULTIVATION 1980

(000' feddans)

	Irrigated Gravity [1]	Irrigated Gasoil Pump	Irrigated Electric	Irrigated Flood	Mechanized Rainfed	Traditional	Total
Eastern	495.6	9	16.4	--	2,969.9	23	3,513.9
Northern	--	239	35	325	--	--	599
Khartoum	--	13	62	--	--	--	75
Central	1,413.5	230.7	168.1	--	2,052	1,601	5,465.3
Southern	--	25	--	--	500.3	1,552	2,077.3
Kordofan	--	16	--	--	237.9	3,365	3,618.9
Darfur	--	17	--	--	6	2,786	2,809.0
TOTAL	1,909.1	549.7	281.5	325	5,766.1	9,327	18,158.4

1 Includes Rahad scheme listed under Eastern region which also uses electric pumps and presently irrigated 225,000 feddans. Also includes some feddans in Gezira Scheme that are irrigated with gasoil-powered pumps.

TABLE III-13

SCHEMES UNDER IRRIGATION

Province	Name of Scheme or Crop	Crop	78/79		79/80		80/81		Averages		
			area in 000 Fed	prod.in 000 Ton	area in 000 Fed	prod.in 000 Ton	area in 000 Fed	prod.in 000 Ton	area in 000 Fed	prod. in 000 Ton	prod./Fed (Kg)
El Gezira	Gezira	Cotton	498	233	541	203	503	135	514	190.33	370
		Sorghum	344	169	270	110	301	130	305	136.33	447
		Wheat	503	151	376	200	366	180	415	177	527
	&	Rice	4	5	7	5	5	3	5.33	4.33	807
	Managil	Groundnut	217	180	267	250	170.9	98.6	218.30	176.20	807
Total			1566	738	1461	768	1345.9	546.6	1457.63	684.19	--
Blue Nile	Blue Nile	Cotton	81	25	67	14	64	18	70.67	19	269
		Sorghum	57	30	62	19	54	22	57.67	23.67	410
		Maize	41	12	-	-	-	-	41	12	293
		Groundnuts	3	1	2	0.5	1	1	2	0.83	415
		Cotton	33	33	31	11	32	9	32	13	406
	Suki	Groundnut	25	25	32	39	15	15	24	26.33	1097
Total			240	112	194	83.5	166	65	227.34	94.83	--
White Nile	Kosti-Renk	Cotton	61	22	65	10	40	12	55.33	14.67	265
		Sorghum	11	5	3	1	5	2	6.33	2.67	422
	El Dueim	Cotton	21	9	30	7	21	6	24.00	7.33	350
		Wheat	5	1	2	1	3	1	3.33	1	300
		Sorghum	33	15	28	10	24	9	28.33	11.33	400
	Private pump Sche.	Cotton	6	3	3	1	3	1	4.00	1.67	418
Total			137	55	131	30	96	31	121.32	38.67	--
Grand Total			2486.6	1115.5	2291.8	2091.9	867.9	867.9	2334.26	1069.38	--

TABLE III-14

AREA AND CROP PRODUCTION OF IRRIGATED SCHEMES BY REGION

Region	Crop	78/79		79/80		80/81		Averages		
		area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod in 000 Ton	area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	prod./Fed (Kg).
Middle Region	Cotton	700	311	737	246	663	181	700	246	351
	Sorghum	445	219	363	140	384	163	397.33	174	438
	Wheat	508	152	378	201	369	181	418.33	178	426
	Rice	4	5	7	5	5	3	5.33	4.33	812
	Groundnut	245	206	301	289.5	186.9	114.6	244.30	203.37	832
	Maize	41	12	--	--	--	--	41	12	293
Total		1943	905	1786	881.5	1607.9	642.6	1806.29	817.70	--
Eastern Region	Cotton	187	69	163	66	167	60	172.33	65	377
	Sorghum	95	42	35	10	74	28	68	26.67	392
	Wheat	47	11	49	14	37	18	44.33	14.33	323
	Castor	28.6	4.5	22.8	2.3	27	5.3	26.13	4.03	154
	Groundnut	68	25	107	116	98	75	91	72	791
Total		425.6	151.5	376.8	208.3	403	186.3	401.79	182.03	--
Northern Region	Cotton	5	3	6	2	6	2	5.67	2.33	411
	Sorghum	50	20	45	19	45	18	46.67	19	407
	Wheat	30	14	30	18	30	19	30	17	567
	Horsebean	33	22	48	38	--	--	40.50	30	741
Total		118	59	129	77	81	39	122.84	68.33	--
Grand Total		2486.6	1115.5	2291.8	1166.8	2091.9	867.9	2330.92	1068.09	--

TABLE III-15

AREA AND CROP PRODUCTION OF MAJOR CROPS UNDER IRRIGATION BY CROPS

CROP	78/79		79/80		80/81		Averages		
	area in 000 Fed.	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	prod./Fed (Kg)
Cotton	892	383	906	314	836	243	878	313.33	357
Sorghum	590	281	443	169	503	209	512	219.67	429
Caster	28.6	4.5	22.8	2.3	27	5.3	26.13	4.03	154
Wheat	585	177	457	233	436	218	492.67	209.33	425
Groundnut	313	231	408	405.5	284.9	189.6	335.30	275.37	821
Rice	4	5	7	5	5	3	5.33	4.33	812
Maize	41	12	-	-	-	-	41	12	293
Horsebean	33	22	48	38	-	-	40.50	30	741
GRAND TOTAL	2486.6	1115.5	2291.8	1166.8	2091.9	867.9	2330.93	1068.06	--

TABLE III-16

AREA AND CROP PRODUCTION BY PROVINCES AND SCHEMES

SCHEMES UNDER IRRIGATION

Province	Name of Scheme or Crop	Crop	78/79		79/80		80/81		Averages		
			area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	area in 000 Fed	prod. in 000 Ton	prod./Fed (Kg)
Northern Province	Northern Private Schemes	Sorghum	15	6	15	6	15	6	15	6	400
		Wheat	25	11	25	15	25	16	25	14	560
		Horsebean	21	13	25	21	--	--	23	17	739
Total			61	30	65	42	40	22	63	37	--
Nile Province	Zeidad	Cotton	5	3	6	2	6	2	5.67	2.33	411
	Nile Private Scheme	Sorghum	35	14	30	13	30	12	31.67	13	410
		Wheat	5	3	5	3	5	3	5	3	600
		Horsebean	12	9	23	17	--	--	17.50	13	743
Total			57	29	64	35	41	17	59.84	31.33	--
Kassala Province	Rahad	Cotton	79	41	88	56	91	38	86	45	523
		Wheat	5	2	-	-	-	-	1.67	2	400
		Groundnut	36	15	64	64	63	45	54.33	41.33	761
	Gash	Sorghum	24	7	10	3	20	6	18	5.33	296
		Castor	28.6	4.5	22.8	2.3	27	5.3	26.13	4.03	154
	New Halfa	Cotton	86	24	62	8	56	16	68	16	235
		Sorghum	8	3	15	6	28	12	17	7	412
		Wheat	42	9	49	14	37	18	42.67	13.67	320
		Groundnut	32	10	43	52	35	30	36.67	30.67	836
	Tokar	Cotton	22	4	13	2	20	6	18.33	4	218
		Sorghum	63	32	10	1	26	10	33	14.33	434
Total			425.6	151.5	376.8	208.3	403	186.3	401.80	183.36	--

TABLE III-17

TOTAL AREAS UNDER "PLANNED" MECHANIZED AGRICULTURE: 1970/71-1980/81

(000's Feddans)

	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
Kassala	1,988	1,753	1,470	1,851	2,199	2,315	2,311	2,222	2,250	2,023	2,500
B. Nile	288	334	471	820	988	653	651	694	419	603	317
W. Nile	14	44	39	58	49	54	145	125	144	168	149
U. Nile	77	138	210	304	271	366	281	296	258	254	262
S. Kord.	19	80	99	144	192	206	414	229	240	207	227
	-	-	-	1	5	5	8	6	-	-	-
TOTAL PLANNED AREAS	2,381	2,349	2,289	3,178	3,704	3,599	3,810	3,572	3,314	3,255	3,455
APPROX. TOTAL UNPLANNED AREAS	714	752	788	1,112	1,482	1,620	1,905	2,322	2,486	2,930	3,510
TOTAL PLANNED AND UNPLANNED AREAS	3,095	3,101	3,067	4,290	5,186	5,219	5,715	5,894	5,636	6,244	6,965

Source: Mechanized Farming Corporation (June, 1982), NEA Agricultural Committee and NEA Staff.

TABLE III-18

AVERAGE IRRIGATION HEADS DURING GROWING SEASON (M)

	Singa	Sennar	Gezira	Kosti	Dueim	Khartoum	Shendi	Dongola	Red Sea & Kassala	Kordofan	Darfur
Cotton	10.0	10.5	7.4	1.8	1.8	--	5.6	--	--	--	--
Groundnut	10.7	8.4	6.9	--	--	--	--	--	--	--	--
Dura	9.7	7.6	4.9	2.3	2.7	--	4.0	5.3	--	--	--
Wheat	--	11.8	9.9	1.3	0.9	9.3	7.1	7.2	--	--	--
Sugar	11.5	10.6	8.5	2.3	--	--	--	--	--	--	--
Perennial Fodder Vegetable, Fruit, Forest	11.5	10.6	8.5	2.3	2.4	8.4	6.3	6.7	25	30	30
Annual Fodder, Crop [illegible]es	9.9	10.0	7.5	1.2	1.2	8.1	5.5	6.3	25	30	30
Rice	--	--	5.9	2.7	--	--	--	--	--	--	--
Kenaf	--	9.6	--	--	--	--	--	--	--	--	--
Sesame	--	--	--	--	--	--	--	--	--	--	--

TABLE III-19

AVERAGE PUMPING HEADS (M)

Month	Singa	Sennar	Gezira	Kosti	Dueim	Khartoum	Shendi	Dongola	Red Sea & Kassala	Kordofan[1]	Darfur
January	10.1	12.2	10.5	1.1	0.9	9.6	7.5	7.3	25	30	30
February	10.9	12.4	11.0	2.0	1.0	9.8	7.8	7.5	25	30	30
March	12.7	12.6	11.2	1.8	1.5	9.8	7.9	7.8	25	30	30
April	14.9	12.6	11.2	2.9	2.9	9.8	7.7	8.0	25	30	30
May	15.9	12.4	11.0	4.1	4.6	10.0	8.0	7.5	25	30	30
June	14.7	11.6	9.8	4.4	5.4	9.8	7.8	7.4	25	30	30
July	11.4	9.2	7.7	3.9	4.7	8.5	6.1	6.7	25	30	30
August	8.2	5.9	2.9	2.3	3.0	5.9	2.9	4.1	25	30	30
September	8.6	6.5	3.2	1.6	2.3	5.9	2.7	3.9	25	30	30
October	10.4	8.8	5.8	1.2	0.9	7.2	4.3	6.4	25	30	30
November	10.7	10.8	8.3	1.1	0.9	8.7	6.2	7.0	25	30	30
December	9.9	11.7	9.8	1.1	0.9	9.2	7.0	7.1	25	30	30

Sources: Calculated from Ministry of Irrigation river level sheets and the book "Preliminary Report on Electrification of Pumping Schemes on Blue and White Niles," by Mohammed Abdel Karim Asakir and estimates by Khartoum Projects office.

[1] Estimates of pumping head varies between 10 and 70 meters at locations within each region.

Irrigation fuel consumption of gasoil per feddan per annum is calculated with a formula using (1) meters of head, (2) cubic meters of water lifted per feddan per year, (3) assumption of an 85% efficiency for the pump, and (4) assumptions of a 25% conversion efficiency of gasoil to effective work. These assumptions and subsequent estimates are currently under extensive review by NEA staff and Agriculture committee members. It appears likely that under current conditions of spare parts shortages and insufficient maintenance, pumping efficiencies estimated here may be somewhat high. Therefore, fuel consumption estimates for pumping may have to be raised. Table III-21 shows the gasoil use rates calculated using the methodology outlined above. In general, for the major crops, fuel consumption for irrigation varies between the equivalent of 34 gallons per feddan for sugar at Sennar (high water requirement, high pumping head) to 2 gallons per feddan for dura at Kosti (low water requirement, low head). In general, irrigation fuel requirements per feddan are three to four times as great along the Blue Nile as along the White Nile, due to the much greater range in the pumping head along the Blue Nile (average difference of 8 meters between maximum in May and minimum in August).

b. Mechanized Agricultural Operation: Mechanized agricultural operations include activities such as tractor use for ridging, plowing by disc plows and disc harrows, and use of heavy tractors in deep plowing for weed control. Tractors are also used to mount herbicides and insecticide sprayers, and to draw fertilizer broadcasters and seeders. Service implements are drawn by tractors in harvesting cotton and groundnuts, and in land preparation. For example, stationary threshers are used in groundnut and dura production. Tractors are also used to draw dredgers used in irrigation canals, and for ditchers used in canal construction. A large canal system is referred to by "Abu", and Roman numerals denominate the number of branches on each canal. Table III-22 presents gasoil use rates per feddan for all agricultural operations for six crops: cotton, groundnuts, sesame, dura, wheat and sugar. These fuel use rates were obtained from reports submitted to the NEA by different schemes as well as from NEA staff visits to each major scheme and from extensive information provided by the NEA's Agricultural Committee. As can be seen in the Tables, large variations were found in the information submitted by the schemes. Total fuel consumption was calculated using the averages of the figures submitted. A summary tabulation is presented in Table III-23, in which averages for all schemes are shown by crop and type of cultivation. These values were multiplied by the feddans under cultivation by crop and type of cultivation to obtain annual fuel consumption for agricultural operations. There are no large variations in these averages. Typical values range from one to three gallons per feddan per year with the exception of the cotton that is mechanically harvested, where fuel consumption averages about 8 gallons per feddan annually (half of which is consumed by mechanical cotton pickers).

TABLE III-20

IRRIGATION M^3/FEDDAN*

	BN Singa	Sennar	Gezira	Kosti	Dueim	Khartoum	Shendi	Dongola	Red Sea & (5) Kassala	Kordofan	Darfur
Cotton(1)	3600	3900	4600	4300	4600	--	5100	--	5100	--	--
Groundnuts	1900	2400	3500	3100	3500	4000	4200	4400	--	--	--
Dura	1700	1900	2700	2400	2700	3700	3400	3500	3400	--	--
Wheat	2600	2700	2900	2800	2800	2800	2800	2600	--	--	--
Sugar	8100	9100	10900	10300	10900	--	--	--	--	--	--
Perennial Fodder,(2) Fruits, Forest	7200	7600	8300	8100	8400	8900	9200	9400	8100	8400	8400
Annual(3) Fodder Vegetables Pulses	3200	3200	3200	3200	3200	3200	3600	3600	3200	3200	3200
Rice	3800	4500	6000	5400	6100	--	--	--	--	--	--
Kenaf (4)	--	--	--	--	--	--	--	--	8900	--	--
Sesame	--	--	--	--	--	--	--	--	--	--	--

1. Average of long & medium staple
2. Assumes 400 m^3/watering 24 waterings/year minus rainfall
3. Assumes 8 waterings of 400 m^3 each to Khartoum, 9 waterings north of Khartoum
4. Assumes 13 waterings of 800 m^3 minus rainfall taken at Medani
5. Rainfall taken at Dueim

* Source 8 - Nile Water Study and NEA estimates

TABLE III-21

IRRIGATION FUEL CONSUMPTION/FEDDAN

(GALLONS)

	Singa	Sennar	Gezira	Upper Nile	Kosti	Dueim	Khartoum	Shendi	Dongola	Kassala	Darfur
Cotton	12.8	14.5	12.1	3.0	3.3	3.4	--	10.1	--	--	--
Groundnuts	7.2	7.2	7.3	--	--	--	--	--	--	--	--
Dura	5.9	5.1	4.7	1.7	2.0	2.6	--	4.8	6.6	--	--
Wheat	--	11.3	10.2	--	1.3	0.9	9.2	7.1	6.6	--	--
Sugar	33.1	34.2	32.9	--	8.4	--	--	--	--	--	--
Perennial Fodder, Fruits, Forest	29.4	28.6	25.0	6.0	6.6	7.2	27.5	20.6	22.4	72	89
Annual Fodder Vegetables Pulses	11.2	11.4	8.5	1.2	1.4	1.4	9.2	7.0	8.1	28	34
Rice	--	--	12.6	9.5	5.2	--	--	--	--	--	--
Kenaf	--	--	--	--	--	--	--	--	--	--	--
Sesame	--	--	--	--	--	--	--	--	--	--	--

Using the formula: Head (meters) x M^3 x 0.355 x 10^{-3} = gallons of fuel

TABLE III-22.A

FUEL CONSUMPTION PER FEDDAN - AGRICULTURAL OPERATIONS FOR COTTON

(GALLONS)

Scheme Operation	Ridging	Green Ridging	Disc Plow	Disc Harrow	Abu XX Opening	Abu XX Leveling	Abu VI Opening	Deep plowing	Fallow plowing	Plowing fallen cotton	Herbicide Spraying	Fertilizer Broadcasting	Seeding	Insecticide Spraying	Cotton stalk Pulling	Machine Picking	Border Const.	Total
Suki	0.48	0.48	1.2	0.6														
Gezira	0.86		0.9		0.25			3.18	0.26	2.34	0.23	0.25	0.74	0.70				
Rahad	0.4 x 2		0.4	1.2		2[a]	0.05						0.3		0.6	4[c]	0.05	9.4
New Halfa Agric. Corp.	0.5 x 2				0.05	2[b]	0.1						0.5				0.1	4.2

a. digging Abu XX

b. Leveling Abu XX

c. 10% of area only machine picked

TABLE III-22.B

FUEL CONSUMPTION PER FEDDAN - AGRICULTURAL OPERATIONS FOR GROUNDNUTS

(GALLONS)

Scheme Operation	Ridging	Green Ridging	Disc Plow	Disc Harrow	Abu XX Opening	Abu XX Leveling	Abu VI Opening	Digging	Threshing	Herbicide Spraying	Border Const.	Plots Division	All Operations thru	Total
Suki	0.48	0.48	1.2	0.6										
Gezira					0.25			1.35	5.28	0.45				7.33
Rahad													2.8	2.80
New Halfa Agric. Corp.	0.5	0.5 X2		0.5 X2	0.5	2.0	0.1 X2	1.0	2.0		0.1 X2	0.1	Seeding 0.5	9.0

TABLE III-22.C

FUEL CONSUMPTION PER FEDDAN, AGRICULTURAL OPERATIONS FOR

(GALLONS)

Scheme Operation	Plowing	Plowing & Seeding	Total
Mechanized Farming Corp.	0.5	0.5	i

TABLE III-22.D

FUEL CONSUMPTION PER FEDDAN - AGRICULTURAL OPERATIONS FOR

(GALLONS)

Scheme Operation	Herbicide Spraying	Abu XX Opening	Land Preparation	Abu VI Opening	Border Construc-tion	Plowing	Seeding	Harvesting + Services	Total
M. F. C.						0.5	0.5	1.0	2
Gezira	0.45	0.25							0.7
Rahad			0.8						0.8
New Halfa Agric. Corp.		0.5	1	0.1	0.1				1.7

TABLE III-22.E

FUEL CONSUMPTION PER FEDDAN, AGRICULTURAL OPERATIONS FOR

(GALLONS)

Scheme Opera-tion	Disc Deep Plowing	Land Leveling	Land Preparation	Seeding	Light Plowing	Border Construc-tion	Abu XX Leveling	Abu XX Opening	Abu VI Opening	Terra-cing	Seeding	Harvesting + Services	Total
Gezira	2.76	3.58	0.81	0.66									7.81
New Halfa Agric. Corp.					0.5 x2	0.1	2.0	0.5	0.1	0.5	0.5	1.0	5.70

TABLE III-22.F

FUEL CONSUMPTION PER FEDDAN-AGRICULTURAL OPERATIONS FOR SUGAR

(GALLONS)

Scheme Operation	D8 Bush Cleaning	D8 Plowing	D5 Land Planning	J/D 4230 Ridging	Roads & Canals	Semi-Trailer	Mechanical Harvester	Support Equipment	Total
Kenana	1.62	3.75	0.97	0.93	1.40	11.18	5.51	1.75	27.11

TABLE III-23

ALL AGRICULTURAL OPERATIONS THROUGH HARVESTING

FUEL CONSUMPTION

(GALLONS)

	Irrigated Hand Harvested	Irrigated Heavily Mechanized (e.g., Rahad)	Mechanized Rainfed Light Soil	Mechanized Rainfed With Heavy Soil or Weed Control
Cotton	4.1	8.1		
Groundnuts	.6	3.0		
Dura	1.1	1.6	1.3	1.7
Wheat	1.4	1.9		
Sugar				
Perennial Fodder Fruits, Forest				
Annual Fodder, Vegetables, Pulses	0.4			
Rice	2.0			
Sesame			0.9	1.3

Source: Rahad Agricultural Corporation,
White Nile Agricultural Corporation, Mechanized Agricultural Corporation,
Suki Agricultural Corporation,
New Halfa Agricultural Corporation,
and NEA Estimates

3. INDUSTRY

The Ministry of Industry lists some 231 industries in Sudan ranging from one dozen employees to several thousand employees (in the case of some textile and sugar factories). A full list of these factories is included in Exhibit II, showing the economic activity, number of employees and location of each. Some 75 of these industries were visited by the NEA staff in the course of this assessment. A list of these are shown in Table III-24. The questionnaire used by NEA and project staff for collecting energy consumption data is included in Exhibit III.

A separate detailed diagnosis of the current status of industry in the Sudan that addresses major production bottlenecks, efficiency of utilization of energy and other, non-technical, problems is contained in the report "An Examination of the Impact of Energy Supply Problems on Sudanese Industry and a Review of Energy Use and Energy Efficiency," prepared for the National Energy Assessment. An indication of the poor performance of industry is shown in Table III-25 that lists current utilization rates and installed capacity for major subsectors. There are important consequences on energy efficiency implicit within these low utilization factors, because energy consumption per unit of output is much greater at lower levels of capacity utilization than at higher levels. The primary reason for this phenomenom is that as much as 50% of total energy can be consumed in air conditioners, lighting and so on, in a particular factory. This energy consumption can be considered "fixed", as it is relatively constant, whatever the level of capacity utilization. Other types of energy consumption vary with output. In general, however, for even the variable portion of total energy consumption, usage per unit of output increases as capacity utilization decreases. Table III-26 illustrates these points. (These figures are based on conditions prevailing in Europe but it is felt that they are generally applicable to Sudan). Note that in the textile industry, at 20% capacity utilization total energy consumption is still 62% of what it would be if 100% of capacity was being utilized. Consumption per unit of production is over three times what it would be at 100% capacity utilization.

While the decline in energy efficiency that accompanies low rates of capacity utilization is more severe in textiles than in other industries, it is clearly significant in all factories.

Table III-27 shows the effects of this on Sudanese industry. It is apparent from this table that increasing capacity utilization is a key factor in improving energy efficiency.

Brickmaking and bakeries were investigated in detail because of their high use of woodfuel and charcoal. Nearly 90% of fuel oil used in industry is used in the first four subsectors listed, as is 71% of all purchased electricity. Self-generation of electricity in the sugar subsector alone nearly matches the total industrial purchases of electricity from the NEC. Energy use in the industrial sector by the major subsectors is summarized in Table III-28; Table III-29 shows a breakdown by region.

TABLE III-24

NEA INDUSTRIAL ENERGY ASSESSMENT
(FACTORIES VISITED)

PLANT/FACTORY NAME	LOCATION	DATE OF VISIT
Oil and Soap		
1. African Oil and Soap Corp.[1]	Khartoum North	25. 1.81
2. Bittar Soap Factory[1]	" "	23.11.81
3. Sheikh Mustafa Oil Mills[1]	Port Sudan	31.10.81
4. Olyab Oil Mills[1]	" "	31.10.81
5. Malik Oil Mills[2]	Khartoum North	8.81
6. Sudanese Oil and Soap Corp.[2]	" "	8.81
7. El-Koubani Oil Mills[2]	" "	11.81
8. El-Taital Oil Factory[2]	" "	11.81
9. El-Mahdi Oil Mills[2]	" "	11.81
10. Mouhat Oil Mills[2]	" "	11.81
Textiles		
11. Arab Weaving Company[2]	Khartoum	10.81
12. Friendship Textile Mills[1]	El-Hasaheisa	10.81
13. Cotton Textile Mills(CTM)[1]	Gezira	9.81
14. Sudan Textile Mills[1]	Khartoum North	9.81
15. Red Sea Spinning and Weaving[1]	Port Sudan	4.11.81
16. Blue Nile Spinning and Weaving[1]	Gezira	10.81
17. Wad Medani Textile[1]	Wad Medani	10.81
18. International Spinning and Weaving[1]	Port Sudan	2.11.81
19. Khartoum Spinning and Weaving[1]	Khartoum North	10.81
20. Hag Abdalla Spinning[2]	Hag Abdalla	22.10.81
21. Shendi Spinning and Weaving[1]	Shendi	4.11.81
22. Kadugli Weaving[2]	Kadugli	4.82
23. Sennar Spinning[1]	Sennar	22.10.81
24. Port Sudan Spinning[1]	Port Sudan	5.11.81
Sugar		
25. Khashm El-Girba Sugar[1]	New Halfa	11.81
26. Sennar Sugar[1]	Sennar	10.81
27. El-Guneid Sugar[1]	El-Guneid	10.81
Flour		
28. Abdo Rabo Flour Mills[1]	Port Sudan	5.11.81
29. Flour Mills Sudan[1]	Khartoum	8.11.81
30. Atbara Flour Mills[1]	Atbara	2.11.81
Metalworking		
31. Standard Household Manufacturers[1]	Khartoum North	10.81

[1] Indicates complete energy questionnaire administered with plant visit.
[2] Indicates short visit only, with less than complete questionnaire completed.

TABLE III-24 (continued)

32. El-Nilein Industries[1]	Khartoum	10.81
33. Abu Agla Pipe Factories[1]	"	10.81
34. Khartoum Central Foundry[1]	"	9.11.81
35. Sudanese Steel Products[1]	Khartoum North	11.81
36. Coldair Engineering[1]	" "	11.81
37. Sheet Metal Industries[1]	" "	30. 5.81
38. White Nile Factory for Tins[2]	" "	4. 6.81
Clothing/Apparel		
39. Bata Sudan[1]	Khartoum North	11.11.81
40. Salwa Ready Made Clothing[1]	" "	11.81
41. National Blanket[1]	" "	11.81
42. El-Nilein Clothes[2]	" "	11.81
43. Asindico Clothes[2]	" "	11.81
44. El-Trico Clothes[2]	" "	11.81
45. El-Amuya Clothes[2]	" "	11.81
46. Hillal Footwear[1]	Omdurman	30.11.81
Tanneries		
47. White Nile Tannery[1]	Khartoum	11.81
48. Khartoum Tannery[1]	"	11.81
49. El-Gezira Tannery[1]	Wad Medani	9.81
Ice/Refrigeration		
50. Yassin and El-Tigani Ice[2]	Omdurman	11.81
51. Modern Icecream and Sweets[2]	Khartoum	11.81
52. National Ice Freezing[2]	Khartoum North	11.81
53. Tigani El-Brigader Ice[2]	Omdurman	11.81
54. Abu Rigeilla Ice[1]	"	11.81
55. Abu Rigeilla Ice Cooling[2]	"	11.81
Miscellaneous		
56. Kaso Plastics[1]	Khartoum North	13. 5.81
57. El-Kheir Plastics[1]	Omdurman	5.12.81
58. Rainbow Plastics[1]	Khartoum North	20. 5.81
59. El-Roubi Accumulators[1]	" "	27.10.81
60. Sudanese Glass[1]	" "	27.11.81
61. Modern Acetylene and Oxygen[1]	" "	21.11.81
62. Blue Nile Packing[1]	" "	23.11.81
63. Khartoum Biscuits[1]	Omdurman	11.81
64. Blue Nile Brewery[1]	Khartoum North	12.11.81
65. Haggar Cigarette and Tobacco[1]	" "	11.81
66. Medical Sanitary Products[1]	" "	11.81
67. Union Carbide Sudan[1]	" "	14.11.81
68. Port Sudan Refinery[1]	Port Sudan	10. 6.81
69. Karam Biscuits[1]	Omdurman	10.11.81
70. International Tyre[1]	Port Sudan	6.11.81
71. Maspio Cement[1]	Atbara	30.10.81
72. Sudanese Chemical Industries[1]	Khartoum North	28. 5.81
73. Ghazala Leather and Plastics[1]	Omdurman	2.12.81
74. Medical and Health Products[1]	Khartoum North	30. 5.81
75. Said Food Canning[1]	" "	5.81

TABLE III-25

CAPACITY UTILIZATION IN SELECTED INDUSTRIES 1980

Industry	Designed Capacity	Actual Production	Utilization %
Sugar	640,000 Tons	111,000 Tons	17%
Cement	300,000 Tons	173,000 Tons	58%
Textiles Spinning Only	16,800 Tons	5,565 Tons	33%
Other Textiles			
Public	53.8 million meters	11.1 million meters	21%
Private	236 million meters	87.3 million meters	37%
Flour	381,000 Tons	235,000 Tons	62%
Oil[1]	1.03 Million Tons	.495 Million Tons	48%

[1] Cotton Seed, groundnut, sesame

Sources: Ministry of Industry Statistics Department and Public Industrial Corporation's unpublished data; Ministry of Finance and National Economy Economic Survey 1980/81

TABLE III-26

COMPARISONS OF ENERGY CONSUMPTION AT GIVEN LEVELS OF CAPACITY UTILIZATION

Industry	Capacity Utilization	Relative[1] Energy Consumption	Relative[2] Energy Consumption Per Unit Output
Textile	100%	100%	100%
	80%	93%	116%
	60%	83%	138%
	40%	74%	185%
	20%	62%	310%
Cement	100%	100%	100%
	80%	89%	111%
	60%	74%	122%
	40%	60%	150%
	20%	40%	200%
Sugar	100%	100%	100%
	80%	90%	113%
	60%	77%	126%
	40%	64%	161%
	20%	47%	232%
Oil Seed	100%	100%	100%
	80%	90%	111%
	60%	75%	125%
	40%	62%	155%
	20%	44%	220%

1 Energy Consumption relative to what it would be at 100% capacity utilization.
2 Energy Consumption per unit of output relative to that at 100% capacity utilization.

TABLE III-27

ENERGY CONSUMPTION IN SUDANESE INDUSTRY

Industry	Capacity Utilization	Relative Consumption	Relative Energy Consumption Per Unit Output
Textiles (Spinning only)	33%	70%	229%
Textiles (Public)	21%	63%	304%
Textiles (Private)	37%	72%	204%
Cement	58%	61%	125%
Sugar	17%	47%	232%
Oil Seeds	48%	67%	143%

TABLE III-28

INDUSTRY ENERGY CONSUMPTION 1980

(units as shown)

Sub-sector	Kerosene and LPT Tons	Gasoil Tons	Diesel Tons	Furnace Oil Tons	Wood Tons	Crop Residues Tons	Purchased Electricity Gwh	Generated Electricity Gwh
Textile	small	10,064	--	14,058	--	--	79.9	29.7
Cement	small	927	3,431	19,724	--	--	3.8	10.1
Sugar	small	11,300[2]	--	37,720	--	430,000[1]	58.8	232
Oil & Soap	small	5,309	132	19,479	29,600	42,500	30.8	12.7
Brick making	small	--	--	--	90,000	--	--	--
Bakeries	small	4,200	--	--	96,500	--	--	--
Miscellaneous	small	10,000	2,702	13,350	6,900	--	--	29.6
TOTAL	900 Kerosene 750 LPG	41,800	6,265	104,331	223,000	472,500	173.3	314.1

[1] Assumes 3 tons bagasse = 1 ton furnace oil, 15% thermal efficiency; total bagasse production was 915,000 tonnes.

[2] Total gasoil consumption including transport was 16,000 tons.

Source: NEA Surveys and Petroleum Distribution Company sales data.

TABLE III-29

INDUSTRY ENERGY CONSUMPTION 1980*

Region / Fuel	Kerosene and LPG Tons	Gasoil Tons	Diesel Tons	Furnace Oil Tons	Wood Tons	Crop Residues Tons	Purchased Electricity Gwh	Generated Electricity Gwh
Eastern	small	17,800	--	13,915	19,100	87,000	8.5	78.3
Northern	small	1,600	4,993	15,319	18,000	--	.4	11.7
Khartoum	small	8,500	872	24,473	68,200	--	114.5	16.7
Central	small	10,000	400	50,381	42,200	343,000	118.4	206
Southern	small	small	--	--	23,100	--	--	.1
Kordofan	small	1,300	--	243	35,300	23,600	--	1.5
Darfur	small	600	--	--	17,050	18,900	.7	.4
TOTAL	900 Kerosene 750 LPG	39,800	6,265	104,331	222,950*	472,500	242.5	314.7

1. Assumes 3 tons bagasse = 1 ton furnace oil, 15% thermal efficiency; total bagasse production was 915,000 tons.

2. Total gasoil consumption including transport was 16,000 tons.

Source: NEA surveys and Petroleum distributing company sales data.

* Data may not correlate precisely with Table III-23, due to difficulties in assigning transported fuel to a particular region.

a. Textiles: This subsector represents the largest industrial activity in the Sudan. It is concentrated in the Central Region, the Khartoum area, and in Port Sudan. Fuel consumption was obtained from seven major factories. The single major factory not visited, Sennar Spinning, was estimated on the basis of other factories (Red Sea and International Spinning). Only two of the seven weaving sheds were visited (Shendi and Kadugi Weaving), and energy use at the other identical facilities was estimated on the basis of these visits. Supplementary information on all textile plants was obtained from the Textile Corporation, the petroleum distribution companies, the NEC, the Ministry of Industry and through the work and research completed by P. Thorne and M. Milukas on Energy Use in Industry. Thorne and Milukas' work is summarized in a lengthy report which appears as an annex to the assessment report. This report contains an extensive diagnosis of the many problems (not just energy) that plague Sudanese industry and that have brought overall industrial capacity utilization down to a low of 30%.

b. Cement: Two factories produce cement in the Sudan. Their combined production in 1980 was 185,000 tonnes. The cement subsector is well documented in various feasibility reports for capacity expansion and rehabilitation which include fuel oil and electricity requirements. Data is also available from petroleum distribution companies, the NEC, the Ministry of Industry and the Industrial energy questionnaires submitted by the NEA during plant visits.

c. Sugar: Three of the five sugar factories (Sennar, Khashm El-Girba and El-Guneid) were visited by members of the assessment team. NEA questionnaires were collected for all five factories.

d. Oil and Soap: The oil industry is a major agro-industrial activity in the Sudan, and is particularly important in the economy of Western Sudan. In contrast to the subsector highlighted above, the oil and soap industry is relatively dispersed. There are presently 80 oil mills which employ more than 4000 workers and 28 soap factories which employ more than 2000 workers. About 30% of the industry is located in Kordofan and Darfur (i.e., Western Sudan) and 20% in the Khartoum area. The installed capacity of the oil mill industry reaches 1 million tons but actual production is only 45% of this. While domestic production of raw materials for this subsector is not a major reason for the low utilization factor, infrastructure problems, such as bottlenecks in the transportation of groundnuts to processing mills, lack of power, fuel and foreign exchange for spare parts, all contribute to low capacity utilization in this subsector.

Fuel consumption data were obtained from factory questionnaires, visits by NEA staff, petroleum companies, and the Ministry of Industry. In order to estimate fuel use for factories and mills that were not contacted, the following energy coefficients were used: furnace oil for raising steam at 0.33 tonnes per tonne of oil produced, gasoil used to raise steam in stationary locomotives (in Western Sudan) at 30 gallons (IG) per shift, per unit and 330 shifts per year, per unit. Groundnuts processed in Western Sudan also use discarded hulls for the production of steam, at the rate of some 7.5 tonnes of groundnuts per day (and 210 days per year). Firewood use in the Western oil mills was estimated at 15m3 per day.

e. Traditional Industries: Estimates were made on the amounts of firewood used in bakeries and in brickmaking since no direct source of information exists for these industries. For bakeries, a rate of 792 Kcal per kg of bread was used. Total amounts of bread baked were estimated from the quantities of flour distributed to bakeries as reported by the Ministry of Commerce. Data for brickmaking was obtained from the Institute of Building Research; a rate of 57 Kcal per tonne of bricks was used. Firewood is the only energy source used. A regional breakdown of brickmaking was also estimated.

f. Other Industries: Most of the industrial subsectors not included above that use relatively large amounts of energy are located in the Khartoum or Port Sudan areas. They include plastics, pharmaceuticals, chemicals, icemaking and tanneries. Energy consumption data was collected directly from those industries by the NEA staff.

4. TRANSPORT

The transport sector consumes 57% of total petroleum consumed in the country, and of this over 80% is consumed on roads (Table III-30). Consumption of fuels by off-road modes - railroads, river boats, pipeline and aircraft, is well documented by the various agencies and corporations that operate these modes. However, this accounts for only 20% of the sector's fuel consumption. A little over one-third of the fuel consumed by the transportation sector is benzine. Practically all benzine was utilized for road transportation (except for small amounts used in emergency electricity generation).

Another 9% of fuel consumed in the transportation sector is jet fuel and aviation gas. Both are easily quantifiable and assignable to the transport sector.

On the other hand, the 253,000 tonnes of gasoil that have been allocated to the road transport sector in 1980 are not so readily identifiable as the other entries in Table III-30. This estimate was made on the basis of interviews, traffic surveys, statistics on vehicle registrations, and sales statistics of the petroleum distribution companies. The estimate attempts to include all activities pertaining to freight transport by lorries, heavy trucks and other diesel engine road vehicles, regardless whether or not the vehicles are used in the agricultural sector, the industrial sector or by government institutions. This is consistent with the statistics on registered vehicles (Table III-31) for which no distribution of ownership is made.

It is important to note that as a result of the methodology explained above, the estimated gasoil use by road transport in this assessment is higher than those made by the GPC and the petroleum distribution companies. These are also shown in Table III-31. The reason for the difference is that, as mentioned above, the sales of gasoil to the agriculture, industrial and governmental sectors include sizable fractions that are used in road transport; the balance of gasoil which the GPC and distribution companies ascribe to transport is consequently much smaller.

TABLE III-30

FUEL USE IN THE TRANSPORT SECTOR, 1980 ('000 TONNES)

	GASOIL	FURNACE OIL	KERO JET	BENZENE & AVGAS	TOTAL
Rail	26,600	21,900			48,500
River	2,300				2,300
Pipeline	2,700				2,700
Domestic Air	--	--	27,000	6,100	33,100
Int'l Air			17,600		17,600
Heavy Trucks	35,200				35,200
Medium Trucks	176,200				176,200
Khartoum Buses	10,300				10,300
Other Areas, Buses	31,500				31,500
Other Pass. Vehicles Khartoum				121,000	121,000
Other Passenger Vehicles Outside Khartoum				70,000	70,000
TOTAL	284,800	21,900	44,600	197,100	548,400

Source: NEA Transport Committee, Farouk Shalaan and NEA.

TABLE III-31

BENZINE AND GASOIL CONSUMPTION FOR THE ROAD TRANSPORTATION SECTOR

(FREIGHT AND PASSENGER SERVICES)

Year	Gasoil Consumption(1)		Benzine Consumption(1)		#of Licensed Motor Vehicles(2)				Gasoil Motor Vehicles(4)		Benzine Motor Vehicles(5)	
	Total (M.T.)	Road Transport. (MT)	Total (M.T.)	Road Transport. (MT)	Pass. Cars(3)	Buses	Lorries	Boxes and Vans	Total Number	Ave. Cons. (MT/yr/veh.)	Total Number	Ave. Cons. (MT/yr/veh.)
1972	285,602	121,452	147,869	147,869	29,407	2782	15,813	4,955	34,362	3.53	18,595	7.95
1973	314,260	125,704	157,812	157,812	31,663	3084	20,088	6,556	38,219	3.29	23,172	6.81
1974	314,837	126,250	146,462	146,462	38,143	3137	22,908	6,700	44,843	2.82	26,045	5.62
1975	298,682	119,772	141,233	141,233	40,488	3274	30,462	9,385	49,843	2.4	33,736	4.19
1976	352,480	144,164	141,510	141,510	44,631	2952	29,465	10,699	55,330	2.61	32,417	4.37
1977	426,310	167,966	153,804	153,804	52,950	5771	31,100	11,766	64,716	2.6	36,871	4.17
1978	399,490	156,600	165,256	165,256	64,915	6013	33,559	N.A.	N.A.	N.A.	39,572	4.18
1979	433,962	172,714	163,638	163,638	66,817	4973	35,072	N.A.	N.A.	N.A.	40,045	4.09

(1) Source: GPC. Fraction of gasoil and benzine consumption for road transportation was derived from the Shell Company of the Sudan Ltd estimates for gasoil and benzine consumption for 3 sectors (road transportation, Ind. and Agr, River and railways).
(2) Source: Transport Statistical Bulletin (1977, 1978/79, and 1980/81), Transport and Communications Section, Ministry of National Planning.
(3) Traffic Police Dept. in Khartoum estimated that 27% of the passenger cars are not paying license fees and they are not included in the table altogether.
(4) Gasoil motor vehicles are assumed to form the bulk of the buses and lorries fleet.
(5) Benzine motor vehicles are assumed to form the bulk of the passenger cars, box cars and van fleet.

During the course of the National Energy Assessment, several reports have been produced that address the issues of fuel use in vehicles. These are:

- National Energy Administration, Ministry of Energy and Mining: "Traffic Reform and Energy Conservation for Vehicles in the Capital-Khartoum Area," (Dec. 1981).
- National Energy Administration, Ministry of Energy and Mines: "Assessment of Road Freight Movement and the Corresponding Energy Use During 1979/80," (September 26, 1981).
- National Energy Administration, Ministry of Energy and Mines: "Review of the Road Freight Movement Report of September 1981, (March 1982).

A final Transport Sector Report prepared by the assessment team has been completed which details the fashion in which the road transport estimates were prepared based on number of vehicles per vehicle type, fuel use efficiency (grams of fuel per ton-km or per passenger-km) and volume of traffic (ton-km or passenger-km per vehicle per year). These estimates are shown in Tables III-32 to III-35.

Information on rail and river fuel consumption was obtained from Sudan Railways and the River Transport Corporation. Fuel use by the petroleum products pipeline was obtained from the GPC. Air transport fuels correspond to the sales of jet fuel and aviation gasoline reported by the GPC and the petroleum distribution companies for the respective years. Tables III-36 to III-38 present this information.

5. COMMERCIAL AND GOVERNMENT SERVICES

This sector is a set of largely unrelated activities which consume the balance of energy used in the country. It is comprised of retail establishments, office buildings, hospitals, hotels and a broad range of other users that consume 11% of PEWC sales; and restaurants, tea houses and beer houses that consume charcoal and firewood. Also included are activities of the construction industry (buildings and roads) and of petroleum exploration companies. Table III-39 contains a summary of the energy consumed by this sector.

Eight of the most important road construction companies now working in the Sudan were contacted by NEA staff. The consumption of gasoil by petroleum exploration companies is recorded by petroleum distribution companies. The information gathered from these sources showed an estimated 22,000 tons of gasoil used by these firms for transport (and included in transport fuel use). Other uses of fuel accounted for 33,000 tonnes of gasoil used in the commercial, government and services sector.

For estimating firewood and charcoal consumption in the services sector, Sudan was divided into its seven administrative regions. Consumption in the services sector was then calculated for each region separately. The 1973 census was used to determine rural, urban, and total population in each region.

The subsectors within each region were defined as follows:

- Restaurants: Places which serve food for people three times a day. Restaurants associated with Class 1 hotels are not included here;
- Tea Houses: Places which provide tea and coffee during the entire day;
- Clubs and Cinemas: Places which provide entertainment at night hours;

TABLE III-32

HEAVY TRUCKS

(1)	Number of Vehicles	2000[a]
(2)	Fuel Use Rate (Gasoil) grams/ton-km	22 approx[b]
(3)	Km/I.G.	9[c] (approx 5 miles per U.S. gallon)
(4)	Vehicle Utilization Rate Km per year per truck	40,000
(5)	Ton-km per year	1600x10^6 [d]
	Fuel Use per year ('000 tonnes)	
	(2) x (5)	35.2
	(4)÷(3) x (1)÷253.3 I.G./tonne	35.1

a. Vehicle registrations for 1979 report 2736 heavy trucks, of which 696 are owned by the government.

b. Source: Farouk Shalaan, NEA Transport Advisor, estimate.

c. For a 25 ton truck, 0.80 load factor: multiply 25 ton x 0.80 x 22 gm/ton-km x 253.3 I.G. per tonne of gasoil which results in 9.0 km/I.G.

d. 25 ton-truck x 0.80 x 40,000 km/year x 2000 trucks.

Note: I.G. = imperial gallons.

TABLE III-33

SMALL AND MEDIUM SIZED TRUCKS CHART

(1)	Number of Vehicles	28,500[a]
	Fuel Use Rate (gasoil) Surfaced Roads	
(2)	Grams/ton-km	33[b]
(3)	Km/I.G. Dirt Roads	25 (13 mpg)
(4)	Grams/ton-km	60[b]
(5)	Km/I.G. Vehicle Utilization Rate	14 (7 mpg)
(6)	Km per year per truck	26,600
(7)	Ton-km per year	$3,641 \times 10^6$ [c]
(8)	Fuel Use per year ('000 tonnes) (7) x 48 gm/ton-km or (6) ÷ 17 km/I.G. (average) x (1) ÷ 253.3 I.G./ tonne	170,200

a) Vehicle registrations for 1979 stood at 25,190 units. In addition, some 8700 gasoil powered medium sized trucks owned by the governments are licensed.

b) Source: Farouk Shalaan. The weighted average is 48 grams/ton-km approximately. To obtain equivalent in km/I.G., assume 6 ton truck and 0.80 load factor.

c) 6 ton truck x 0.80 x 26,600 km/year x 28,500 trucks.

Errors due to roundoff.

I.G. = imperial gallon

TABLE III-34

FREIGHT TRANSPORT - 1980

	Tonne-Kms 10^6	%	Gasoil '000 tonnes	Furnace Oil '000 tonnes	Fuel Use Rate grams/ ton-Km
Rail	1908	25	26.6	21.9(1)	10
River	48	-	2.3	-	42
Pipeline	300	4	2.7	-	9
Heavy Trucks	1600	21	35.2	-	22
Small/Medium Trucks	3641	49	176.2	-	33-60(2)
Air	7	-	(3)		
	7504	99	243.0	21.9	

(1) A planned phase-out of furnace oil, steam-powered locomotives to diesel engines will lead to large oil savings. A total replacement of 1980 use levels corresponds to 29.7 thousand tonnes of gasoil equivalent, of which 24.1 thousand correspond to freight and 5.6 thousand tonnes correspond to passenger rail.

(2) The lower usage rate corresponds to primarily paved routes, the higher rate to dirt tracks.

(3) Fuel use by Sudan Airways is included entirely under passenger transport.

TABLE III-35

FUEL CONSUMPTION

FOR PASSENGER VEHICLES IN KHARTOUM AREA - 1980

	Private Autos	Taxis	"Boxcars"	Delivery Vans	Mini-Buses	Buses	Total
No. of Vehicles in operation(1)	40,500	7,500	3,000	2,500	1,100	900	--
km/vehicle-yr	17,300	45,000	32,000	30,200	42,000	38,200	--
Fuel Use Efficiency (km/imp. gallon)	35	30	25	30	20	125	--
Total benzine Consumption (tonnes)	65,000 53%	36,526 30%	12,468 17%	8,171 7%	1,500 1%	--	123,165 100%
Total gasoil consumption (tonnes)	--	--	--	--	--	10,268	10,268
Average passengers per vehicle	2.08	1.62	9.14	goods	11	40	--
Passenger-km (106)	1,457	547	877	NA	508	1,375	4,764
Grams Benzine/ pass.-km	44.6	66.8	14.2	NA	14.1	7.5	--

Source: NEA traffic survey of Khartoum area carried out during September and October 1981.

(1) Modified from data on vehicle licenses to account for unlicensed vehicles and vehicles that are out of circulation.

TABLES III-36

RAIL STATISTICS

Fuel Consumption (Tonnes)

	Diesel	Furnace Oil	Total
1976	31,183	41,639	72,822
1977	28,900	27,643	56,543
1978	31,057	22,249	53,306
1979	22,738	22,731	45,469
1980	26,600	21,900	48,500

Volume of Freight and Passenger Traffic (million)

	Tons	Ton-Km	Pass-km	Passengers
1970/71	3.02	2,683	1,033	3.42
1977/78	2.13	2,004	1,192	3.03
1978/79	1.92	1,821	1,057	2.44
1979/80	2.12	1,908	1,070	2.33
1980/81	1.62	1,506	1,033	2.95

Source: Sudan Railways, GPC.

TABLE III-37

RIVER TRANSPORT STATISTICS

Fuel Use ('000 tonnes)

Year	Diesel	Furnace Oil
1976	4871	6
1977	3491	51
1978	3327	92
1979	3268	34
1980	2300	34

Activity Level

Year	Freight (tons, 000)	Ton-km (million)	Passengers ('000)	Pass-km million
72/73	111	88	296	87
73/74	91	74	182	84
74/75	101	83	229	88
75/76	110	90	309	88
76/77	107	94	233	68
77/78	102	89	255	114
78/79	106	65	140	54

Source: River Transport Corporation

TABLE III-38

PIPELINE STATISTICS

Year	Fuel Pumped Tonnes	Million Tonne-km	Fuel Consumption (Tons)	Consumption Ton-Km (gm)
1977	190,377	152.3	1548	10.16
1978	336,166	268.9	2442	9.08
1979	335,090	268.1	2375	8.86
1980	374,209	299.4	2703	9.03

Source: NEA, PPPPC-GPC and September 26, 1981, NEA Transport Report.

TABLE III-39

GOVERNMENT, COMMERCIAL AND SERVICES ENERGY CONSUMPTION 1980

Sub-sector or End Use / Fuel	Gasoil Tonnes	Purchased Electricity GwH	Generated Electricity GwH	Wood Tonnes	Charcoal Tonnes
Petroleum Exploration[2]	10,000	--	u.k.	--	--
Round & Building Construction[2]	23,000	--	u.k.	--	--
Gov't & Comm'l Buildings	800[3]	75.7	2.4	--	--
Eating Places and Laundries	--	small	--	259,340	135,810
Water Pumping	8,000	17.0[1]	--	--	--
Street Lighting	--	8.8	--	--	--
Utility Use	--	8.4	--	--	--
Total	41,800	109.9	2.4+	259,340	135,810

1 Thought to be 67% of inter-departmental tariff throughout Sudan, as is the case in Khartoum.

2 Estimated gasoil consumption including the portion counted in transport sector is 18,700 Tons for Exploration and 58,300 Tons for Construction.

3 Fuel for generators.

Source: NEA Surveys and petroleum distribution company sales data.

u.k.: Unknown

- Schools and Hospitals: Boarding schools and hospitals which provide three meals/day for their residents.
- Prisons: self-explanatory.
- Local Beer Houses: Places which make and sell alcoholic drinks.
- Laundries: Charcoal is used for heating water and washing clothes.
- Buffets: Serve only breakfast and tea during day-time, and are mainly associated with government offices in large towns.

The estimation methodology used was as follows:

- Restaurants and Tea Houses: Found mainly in urban areas. The number of such was calculated in proportion to the total urban population.
- Clubs: These are found both in rural and urban areas. The number was calculated in proportion to the total population in each region.
- Local Beer Houses: The number in each different region was estimated according to the traditions and the culture of each region and the population found there, except for the southern region, where the estimate was based on NEA surveys.

In each region surveyed by NEA an average daily consumption in each sub-sector was obtained and these were summed and averaged. The resulting figure represented an average consumption for each sub-sector. Laundries were assumed to be found in urban areas. The number of laundries calculated for each region was based on a percentage of the urban population. They were estimated as 0.1% of urban population (i.e., for each 1,000 houses there is one laundry). Main towns associated with buffets (mainly located in government buildings) are: Khartoum, Port Sudan, Wad Medani; the number of buffets in big towns was estimated according to the number of government buildings. In other small towns the actual number of buffets was obtained. Tables III-40 and III-41 show estimates of firewood and charcoal consumed by this sector, broken down by subsector and by region respectively. A total of 135,800 tonnes of charcoal and 259,300 tonnes of firewood are consumed by such services.

TABLE III-40

CONSUMPTION OF CHARCOAL AND FIREWOOD IN THE DIFFERENT SERVICES SUB-SECTORS IN TONS/YEAR

Sub-Sector	Charcoal Consumption Tons/Year	Firewood Consumption Tons/Year
Restaurants	58,847	---
Tea Houses	22,208	---
Clubs	2,768	---
Schools	44,820	---
Prisons	---	45,255
Local Beer Houses	---	214,086
Laundries	6,075	---
Buffets	1,094	---
TOTAL	135,810	259,340

TABLE III-41

REGIONAL CONSUMPTION OF CHARCOAL AND FIREWOOD IN THE SERVICES SECTOR IN TONS/YEAR

Region	Total Consumption of Charcoal Tons/Year	Total Consumption of Firewood Tons/Year
Eastern	21,150	13,287
Southern	16,620	85,115
Western	13,140	10,989
Khartoum	15,150	7,393
Central	23,370	21,678
Kordofan	26,640	66,434
Darfur	19,740	54,446
TOTAL	135,810	259,340

IV. AGGREGATE SUPPLY/RESOURCE SECTORS

1. PETROLEUM

The consumption of petroleum products has been analyzed in detail in the previous chapter. Total consumption in 1980 for each product has been obtained from sales records of the GPC, i.e. consumption has been equated to sales. The GPC in turn, obtains its products from two sources: the Port Sudan Refinery, and by directly importing the remainder. Fuel oil for which there is no domestic demand is exported.

Production at the Port Sudan Refinery Ltd. is presented in Table IV-1. These products are blended before delivery to the GPC, with most of the production of kerosene blended into either gasoil (to maximize the output of this product in high demand) or long residue to produce a number of furnace oil types of different viscosities. Petroleum products delivered to GPC are shown in Table IV-2. The difference between refinery production and refinery deliveries should be ascribed to changes in stocks at the refinery (for which no statistics are kept), but calculations of this difference for 1979 and 1980 show relatively large balance. In those years a marked shift in blending practices from "lighter" to "heavier" furnace oil was undertaken, which may explain this statistical aberration.

There have been two distinct periods in refinery operations: 1965-73, and 1974 to the present. During the first period, refinery throughput was raised from nearly 600,000 MT per year to 1.14 million MT in 1973. After 1974 refinery throughput began to show a slow decline that has continued to the present, and output increasingly shifted toward refining middle and high distillates (i.e. gasoil and benzine). Fuel oil (long residue) and kerojet throughput on the other hand declined proportionally to refinery intake. This has hurt the overall economic performance of the refinery, since surplus furnace oil is exported and helps pay for crude imports.

Total crude intake in 1980 was 1,038,600 tonnes, equivalent to the amount of crude imported that year. In addition, 286,596 tonnes of refined products were imported directly, as shown in Table IV-3. As can be seen in that chart and in Table IV-4, the combination of decreased output at the refinery and the rapid growth in demand for refined products, in particular gasoil, benzene and kerosene, has evolved into a situation in which nearly one half of gasoil consumption had to be imported in 1981, whereas only insignificant amounts were imported up to the mid 1970's. By 1982, imported gasoil was significantly higher than refinery deliveries that year.

In Table IV-5, an attempt is made to corroborate for 1980 the information on refinery deliveries and imports, with that on consumption (i.e. GPC sales). It should be noted that consumption, in column (4) in the chart, corresponds to the values in the overall energy balance shown in Chapter I of this report. Consumption as noted earlier, corresponds to reported sales by the GPC.

The column labelled "Difference" is obtained as noted. These differences can be ascribed to changes in stock within GPC, which they do not record.

TABLE IV-1

PORT SUDAN REFINERY LIMITED

CRUDE OIL AND REFINED PRODUCTS THROUGHPUT[1]

Year	Butane	Benzine[2]	Kerosene & Jet Fuel	Gasoil	Long Residue	Ref. Fuel	Total Intake
1972	2,370	147,869	161,374	285,602	452,822	49,653	1,099,690
1973	2,773	157,812	166,379	305,673	452,558	54,156	1,139,351
1974	2,559	146,075	100,757	289,949	435,469	49,652	1,024,461
1975	2,927	141,233	159,946	286,682	458,659	54,552	1,103,999
1976	3,592	136,177	159,115	267,257	454,795	56,650	1,077,586
1977	3,656	138,683	155,194	256,060	459,177	47,582	1,060,352
1978	4,525	145,006	144,824	246,473	424,793	47,067	3,230,954
1979	3,962	138,081	119,811	243,753	381,004	36,838	923,449
1980	4,779	132,515	130,874	354,472	373,441	42,519	1,038,600

Source: Port Sudan Refinery Limited

1 Production before blending of kerosene and long residue to produce the fuels delivered to the GPC: "3500", "1500", "750" furnace oil and other products. Kerosene is also blended into gasoil.

2 Includes Surplus Tops, which were exported until production was halted in 1978.

TABLE IV-2

REFINERY DELIVERIES 1972-1982
(M.T.)

Year/ Product	L.P.G.	Benzine	Kerosene	Jet Avtur	Gasoil	"750" F. oil	"120" F. oil & others	Surplus Tops	Surplus F. oil "3500"	"1500" F. oil	Total
1972	2381	100342	22570	83084	315319	99172	123040	58550	262818	--	1067276
1973	2774	106578	14640	75729	348455	87889	117112	43773	294270	--	1091220
1974	2552	109916	10008	67413	339556	92619	113752	35654	252285	--	1023758
1975	2941	113331	8802	65626	347478	102592	105041	25724	286239	--	1057774
1976	3578	120646	5778	72767	330961	102523	66025	15848	292035	--	1010161
1977	3686	125124	10048	59186	325095	100009	57332	16100	332135	--	1028715
1978	4029	148734	11957	38109	325762	112134	51791	45	272357	--	964918
1979	3962	135452	5465	30764	307572	107162	86652	67	207758	--	944854
1980	4791	130508	10868	44624	316667	2251	98559	66	198558	85330	892222
1981	4803	129315	39679		294633	--	--	--	150560	212718	831708
1982	2850	101185	28137		211530	--	--	--	116578	174424	634704

Source: GPC

TABLE IV-3

QUANTITIES OF CRUDE AND REFINED PETROLEUM PRODUCT IMPORTS

(1972-1981)

Year	(A) Quantity Crude Imports (M.T.)	(B) Quantity Crude Product Imports (M.T.)	(A & B) Total Petrol Imports (M.T.)	(B/A) % Ref. Imports to Total Petrol Imports
1972	1,099,640	0	1,099,640	0%
1973	1,139,269	11,923	1,151,192	1%
1974	1,084,461	25,275	1,109,736	2%
1975	1,103,999	12,000	1,115,999	1%
1976	1,077,586	93,944	1,171,530	8%
1977	1,060,332	195,171	1,255,503	16%
1978	1,012,662	174,041	1,186,703	15%
1979	921,449	247,044	1,168,493	21%
1980	1,038,600	286,596	1,325,196	21%
1981	873,962	336,050	1,210,012	28%

Sources: Shell Oil Sudan, Port Sudan Refinery, Ltd., GPC.

TABLE IV-4

COMPARISON OF PORT-SUDAN REFINERY DELIVERIES

(BENZINE, KEROJET, GASOIL) TO IMPORTED REFINED PRODUCTS: 1972-1982

YEAR	BENZINE			KEROJET			GASOIL			IMPORTED REFINED PRODUCTS AS % OF TOTAL PETROLEUM (CRUDE AND REFINED PRODUCTS)
	REFINED P. SUDAN M.T.	IMPORTED BENZINE M.T.	IMPORTED BENZINE AS % OF TOTAL BENZINE %	REFINED P. SUDAN M.T.	IMPORTED KEROSENE M.T.	IMPORTED KERO AS % TOTAL KERO %	REFINED P. SUDAN M.T.	IMPORTED PROD. M.T.	IMPORTED GASOIL AS % TOTAL GASOIL %	%
1972	100,342	0	0	105,654	0	0	315,319	0	0	0
1973	106,578	0	0	90,369	3,336	4%	348,455	8,587	02%	1%
1974	109,916	387	0	77,421	0	0	339,556	24,888	07%	2%
1975	113,331	0	0	74,428	0	0	347,478	12,000	03%	1%
1976	120,646	5,333	4%	78,545	3,388	4%	330,961	85,223	20%	8%
1977	125,124	15,121	11%	69,234	9,800	12%	325,095	179,250	34%	15%
1978	148,734	20,250	12%	50,066	19,000	28%	325,762	153,016	32%	14%
1979	135,452	27,557	17%	36,229	29,278	45%	307,572	190,209	38%	23%
1980	130,508	49,666	28%	55,492	11,231	17%	316,667	225,699	41%	23%
1981	129,315	72,554	36%	39,679	13,889	26%	294,663	249,156	46%	42%
1982	101,185	87,667	46%	28,137	22,090	44%	211,530	333,897[1]	61%	--

Source: GPC

(1) Additional gasoil was imported privately.

TABLE IV-5

PETROLEUM PRODUCTS BALANCE - 1980

(M.T.)

	(1) Refinery Deliveries	(2) Imports Exports	(3) Stocks	(4) Consumption	Difference (1)+(2)+(3)-(4)
Gasoline	130,508	49,666		190,951	10,777
Aviation Gas	0	0	-6071	6,071	0
Kerosene)	10,868	11,231		17,686	4,413
Jet Fuel)	44,624			44,600	24
Gas Oil	316,667	225,699		510,553	17,528
Diesel(1)	--	--		20,407	0
Fuel Oil	384,698	-198,485		170,502	9,589
LPG	4,791	400		5,019	172
	892,156	88,512		965,817	42,503

(1) Diesel is a blend of 70% gasoil and 30% furnace oil

The latest information on GPC sales is prevented in Table IV-6. Levels of product sales in 1980, 1981 and 1982 are a reflection of the increasing difficulties the Sudan experiences in financing petroleum imports as its balance of payments have worsened. The value of these imports nearly doubled between 1979 and 1980, as shown Table IV-7, and since that date Sudan has been effectively unable to respond to increases in the levels of demand for petroleum products.

However, crude imports in 1981 were the lowest since the late 1960's, and imports of crude during the first half of 1982 were 20% lower than in 1981. Moreover, these imports in 1982 included a grant of 300,000 MT of crude from the Government of Saudi Arabia. During 1981, the time between GPC application to the Bank of Sudan for opening a letter of credit(LC) to the actual LC opening through a commercial bank averaged over 21 days and the time between LC application and actual delivery averaged over 37 days. On six different occasions (out of 19 letters of credit opened for crude) in 1981, it took over one month to open a letter of credit and in one case it took 50 days!

Opening LC's for refined imports takes even longer than for crude, averaging one month in 1981. Deliveries averaged a month and a half after GPC applications for opening letters of credit in 1981. In one case it took nearly three months (84 days) to open an LC and over three months from the GPC's application to actual delivery at Port Sudan. Yet, refined product imports continue to grow in both absolute terms and relative to crude imports.

Table IV-6

GPC Sales -- 1980-1982

	1980	1981	1982
Gasoline	190,951	212,247	192,127
Aviation gasoline	6,071	4,074	4,939
Kerosene	17,686	)	10,433
		)62,170	
Jet fuel	44,600	)	41,564
Gasoil	510,553	539,992	544,540[1]
Diesel oil	20,407	18,338	26,024
Furnace oil	170,502	186,603	164,605
LPG	5,019	5,714	5,600
	965,817	1,029,138	989,832

Source: GPC

[1] Excludes private importation

TABLE IV-7

TOTAL VALUE (NOMINAL)* OF CRUDE AND REFINED PETROLEUM PRODUCT IMPORTS
(1972-1981)

Year	(A) Value of Total Crude Imports (000$)	(B) Value of Total Ref. Prod. Imports (000$)	(A+B) Total Value all Petrol Imports (000$)	(B/(A+B)) % Value of Ref Imports to Total Petrol Imports
1972	17,365	0	17,365	0%
1973	22,490	687	23,177	1%
1974	85,291	2,627	87,918	3%
1975	95,381	3,953	99,334	4%
1976	95,088	12,479	107,567	12%
1977	103,893	26,061	129,954	20%
1978	100,907	31,233	132,140	24%
1979	111,620	48,916	160,536	30%
1980	211,111	101,321	312,432	32%
1981	215,869	128,792	344,661	37%

* CIF, Port Sudan

Sources: Shell Oil Company, Port Sudan Refinery, Ltd., GPC.

Several forces seem to be at work here. The GPC draws up an annual schedule (frequently updated) for deliveries of crude to the refinery. This schedule is based upon the GPC's assessment of projected needs thoughout the year (and these needs vary, particularly with the agricultural seasons). Over the past two years, the GPC has applied to the Bank of Sudan for opening an LC an average of three weeks prior to their delivery schedule date, but, as shown in Table IV-8 deliveries very rarely occur within the three week margin set by the GPC. Moreover, the GPC has no idea at any given time whether the time between application for an LC and actual delivery will occur in more than or less time than the three week margin they have chosen. That is, they may receive a crude shipment within one week after application, or two months after application. Moreover, two pending LC's may open during the same week.

Clearly, then, one of the prime causes for varying and decreasing refinery throughput over the past several years lies with the GPC's inability to open LC's in a manner which would allow for regular, scheduled deliveries. Frequent refinery shutdowns and start-ups lead to decreased refinery (and pipeline) operating efficiency, less throughput and the need for more storage facilities. Frequent disruptions in refinery throughput also lead to the need for more refined product imports as a hedge against those disruptions. It seems apparent that until some method is found for securing sufficient foreign exchange for regular supplies of crude to the refinery, little improvement in refinery performance can be expected.

At present, a direct national economic evaluation of costs (in foreign exchange terms) of crude processed through the refinery versus costs of imported refined products in foreign exchange terms reveals that increasing crude imports would not lead to any net foreign exchange savings. This results from the fact that, at present, Sudan consumes less than half of its residual oil output ("3500" residual) and must, in turn, re-export that fuel at a price of approximately $100 less per metric ton than it pays for crude. However, within the next two years, Sudan will cease to export any residual and, at current refinery production levels, will in fact become a net importer of residual fuel.

One of the consequences of the critical shortages caused by the poor financial position of the GPC and the erosion of the refinery performance is that serious distortions are observed in the regional allocation of petroleum products. The "official" GPC regional sales statistics, shown for 1970 and 1980 in Tables IV-9 and IV-10, indicate that fuel consumption would be increasingly concentrated in the Eastern (i.e. Port Sudan) Khartoum and Central regions, whereas in the Western region, consumption declined. NEA surveys and observations do not agree with these statistics, and indicators are that an informal distribution system exists that moves excess fuel from the Eastern and Central regions to other areas.

2. ELECTRIC UTILITIES

a. NEC Power Systems

Electricity is supplied to the public in the Sudan by the NEC (the National Electricity Corporation), by municipalities, by cooperatives and by some large industries which provide electricity to their communities. In this section, only data pertaining to NEC is presented; other forms of public electricity have been included with self-generation systems and are discussed in the following section.

TABLE IV-8

SAMPLE SCHEDULE OF PERIODS BETWEEN GPC APPLICATIONS TO OPEN LETTERS OF CREDIT TO ACTUAL CRUDE DELIVERIES: 81/82

Date GPC Apply to Open LC	GPO Schedule for Arrival Port Sudan	Date LC Opened	Date Crude Arrived Port Sudan	Time From LC Appl. to LC Opening (Days)	Time from LC Appli. to Crude Delivery (Days)
May 12	June 4-8	June 15	July 8	34	57
June 11	June 22-26	July 15	Aug. 2	34	52
July 13	July 26-30	July 20	Aug. 9	7	27
July 22	Aug. 6-10	Aug. 18	Sept. 3	27	43
July 28	Sept. 1-5	Sept. 2	Sept. 28	36	62
Aug. 25	Sept. 17-21	Sept. 23	Oct. 21	29	57
Oct. 9	Oct. 29-30	Oct. 29	Nov. 23	20	45
Nov. 23[1]	Dec. 2	Dec. 1	Dec. 6	8	13
Jan. 11[1]	Jan. 18	Jan. 16	Jan. 24	5	13
Feb. 18[1]	Feb. 20	Feb. 20	Feb. 22	2	4

Source: GPC

[1] These three shipments were purchased from Egypt through official channels; hence time from application for opening LC to actual delivery at Port Sudan was shorter than usual.

TABLE IV-9

PETROLEUM PRODUCTS CONSUMPTION 1970
(TOE)

Fuel / Region	L.P.G.	Benzene and Avgas	Kerosene and Jet	Gasoil	Diesel	Furnace Oil	TOTAL
Eastern	--	11,876	8,133	47,590	7,394	12,010	87,003
Northern	--	4,767	8,029	37,440	4,610	27,830	82,676
Khartoum	--	52,145	23,321	73,600	11,301	100,637	261,004
Central	--	18,522	11,762	87,558	3,988	40,090	161,920
Southern	--	5,166	1,384	5,387	296	3,917	16,150
Kordofan	--	5,093	4,482	22,090	367	14,246	46,278
Darfur	--	3,255	2,174	8,549	--	662	14,640
TOTAL	--	100,824	58,285	282,214	27,956	199,392	669,671

Source: G.P.C.

TABLE IV-10

PETROLEUM PRODUCTS CONSUMPTION 1980
(IN TOE)

Region \ Fuel	LPG	Benzine[1] Avgas	Kerosene Jet A-1	Gasoil	Diesel	Furnace Oil	Total
Eastern	760	26,880	6,032	96,750	9,483	13,358	153,263
Northern	42	5,250	1,144	34,017	7,652	18,428	66,533
Khartoum	4,713	133,980	4,600	134,806	3,156	61,124	342,379
Central	34	25,515	3,224	130,979	524	48,534	208,810
Southern	--	3,255	--	16,120	--	--	19,375
Kordofan	--	4,200	1,560	23,088	--	1,179	30,027
Darfur	--	1,575	832	18,928	--	--	21,335
Remainder*	0	6,300[5]	47,320[2]	76,336[4]	0	21,024[3]	150,980
TOTAL	5,549	206,955	64,712	531,024	20,815	163,647	992,702

* not distributed by region because of difficulty in disaggregating totals

1 estimated by Farouk Shalaan
2 primary Jet Fuel
3 Sudan railways
4 Sudan Railways, river transport, pipeline, commercial, Govt & services, construction & oil exploration
5 Includes aviation gasoline, fuel for small generators.

Source: NEA estimates. Regional distribution estimates are judged to be less precise than those developed by Sector.

The NEC consists of one major grid known as the Blue Nile Grid, one smaller grid in the Eastern Region, and more than 10 additional isolated systems of varying sizes, the most important of which is that of Port Sudan.* In 1980, maximum output of all NEC systems was 230MW of which the Blue Nile Grid was 192MW, the Eastern Grid 11.5MW and Port Sudan 7.6MW. As indicated in Table IV-11, rated capacity of the system was 274MW. Table IV-12 shows total generation and maximum demand for the Blue Nile Grid and Table IV-13 shows the same information for the other systems of the PEWC, as reported by that organization. Most of the electricity generated by the NEC is hydro-electricity from one large facility on the Blue Nile at Roseires and a smaller one downstream at Sennar. A third hydroelectric facility is operated in the Eastern Grid. The remainder of the electricity is generated with diesel generators and gas turbines, except for stream generators in the Khartoum area. Table IV-14 lists the installed capacity of the Blue Nile Grid by generator type and year of installation. The other systems are all diesel generators.

The consumption of fuel by the different systems of the PEWC is shown in Table IV-15. In this table, hydropower is listed as producing 737.8 Gwh. To generate the equivalent power by steam a steam generator would have required 210,000-250,000 tonnes of furnace oil, which is more than three times the amount of petroleum products used by the NEC in 1980. In the same table, total electric generation and total sales are indicated by the respective systems or regions. The table contains several installed systems grouped by region. Northern includes generation stations at Atbara, Berber, El Damer, Shendi and Dongola; Southern includes those in Juba, Wau and Malakal; Kordofan those in El Obeid and Umruaba; and Darfur those in El Fasher and Nyala. The information on fuel consumption was collected by the NEA staff from NEC records; some of these stations were visited by NEA staff while estimates were made for other stations because of inconsistent published records. The detailed facts on each station are shown in Table IV-16.

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* Through Presidential decree the NEC will be responsible for line operations on the Blue Nile and Eastern Grids while Regional authorities will be responsible for power generation and equipment maintenance in their respective regions. See translation of new enabling legislation appended to this Annex.

TABLE IV-11

EXISTING PEWC ELECTRICITY SUPPLY SYSTEMS
(May 1980)

PROVINCES	Rated Output (MW)	Actual Maximum Output (MW)
1. Blue Nile Grid	214.00	192.00
2. El Gourashi	1.0	0.9
3. Eastern Grid	16.8	11.5
4. Atbara	11.0	6.9
5. Por Sudan	11.0	7.6
6. Kassala	3.2	0.4
7. El Obeid	4.1	2.6
8. Nyala	1.6	1.3
9. Um Ruaba	1.4	1.1
10. Shendi	0.9	0.8
11. Juba	1.0	0.8
12. Ed Dueim	2.1	1.5
13. Malakal	1.0	0.2
14. Wau	2.1	0.6
15. El Fasher	1.4	0.7
16. Dongola	0.9	0.9
17. El Geteina	0.2	0.15
Totals (rounded)	274.0	230.00

Source: PEWC 1980 Development Plan.

TABLE IV-12

LOAD GROWTH IN BLUE NILE GRID

Year	Energy Generated (GWh)	Annual Growth (%)	Maximum Demand (MW)	Load Factor (%)
1968/69	293	14.0	57.0	58.8
1969/70	334	14.0	61.0	62.6
1970/71	339	1.5	62.6	61.8
1971/72	379	11.8	74.0	58.4
1972/73	418	10.0	81.6	58.4
1973/74	452	8.4	86.0	59.9
1974/75	489	8.2	93.6	59.6
1975/76	528	8.0	96.0	62.8
1976/77	576	9.1	104.0	62.8
1977/78	667	15.8	126.0	60.7
1978/79	742	12.0	136.9	61.8
1979/80	819	10.0	144.7	64.6
1980/81	841	1.5	157.8	60.8

Source: PEWC Staff Report (March 1982)

TABLE IV-13

STATISTICS FOR OUTLYING STATIONS

1978/79 to 1980/81

SYSTEM	Energy Generation by Year (Gwh)				Maximum Demand by Year (MW)			
	1977/78	1978/79	1979/80	1980/81	1977/78	1978/79	1979/80	1980/81
Eastern Grid	22.0	21.3	21.8	21.0	12.0	5.9	-	5.5
Atbara	19.0	21.4	21.0	22.0	7.0	5.1	5.1	5.1
Port Sudan	32.0	33.0	33.8	36.0	11.0	7.8	6.4	6.5
Kassala	6.0	5.6	5.9	5.9	3.0	1.4	-	1.3
El Obeid	6.0	5.3	3.5	8.9	1.3	1.3	-	-
Nyala	4.0	3.9	4.1	4.7	1.5	1.0	-	-
Um Ruaba	2.0	2.8	2.9	3.2	1.3	0.6	-	-
Shendi	4.0	4.3	4.0	4.0	0.8	0.9	0.9	0.9
Juba	4.0	3.7	4.0	3.2	0.8	0.6	-	1.5
Ed Dueim	3.0	3.7	3.0	3.9	0.7	0.9	-	-
Malakal	0.9	1.0	0.8	0.8	0.4	0.4	0.4	0.5
Wau	1.0	1.8	1.1	1.0	0.5	0.5	-	-
El Fasher	3.0	2.5	3.2	3.6	1.0	0.9	-	-
Dongola	1.0	1.2	1.2	1.2	0.9	0.6	0.6	0.6
El Geteina	0.1	0.5	0.4	0.4	0.2	0.2	-	-
Totals (rounded)	103.0	112.0	111.0	120.0	42.0	28.0	--	--

Source: PEWC Staff Report (March 1982)

TABLE IV-14

PEWC SYSTEM

BLUE NILE GRID
EXISTING GENERATING PLANT

Plant Name	Type	Year Installed	Name Plate Rating (MW)	Present Maximum Output (MW)
Burri	Diesel	1964	15	10
Burri	Diesel	1981	15	15
Burri	Steam	1956	30	10
Kilo X	Gas Turbine	1969	15	13.5
Roseires	Hydro	1971-80	130*	120*
Sennar	Hydro	1962	15	15
Wad Medani	Diesel	1950-67	8	4
Other			2	1.5
			230.0	189.0
Kenana Extension*	Steam		40*	20*
TOTAL			270	209.0

Source: PEWC Staff Report (March 1982)

* Kenana Sugar Complex. Indiactes total amount generated and maximum possible sales to the NEC.

TABLE IV-15

PEWC ENERGY CONSUMPTION GENERATION AND SALES - 1980

Region	Energy Consumption				Electricity Generation	Electricity Sales
	Gasoil Tons	Diesel Tons	Furnace Oil Tons	Hydropower Gwh	Gwh	Gwh
Port Sudan	--	8,404	--	--	35.0	28.0
Eastern	1,429	892	--	20.8	28.9	20.5
Northern[2]	1,409	2,509	3,877	--	27.9	22.6
BNG	6,321	2,336	39,477	717.0	811.5	600.2
Isolated BN	1,690	--	--	--	6.1	4.8
Southern[1]	5,120	--	--	--	5.5	4.5
Kordofan	2,170	--	985	--	9.3	0.2
Darfur	2,280	--	--	--	7.8	5.8
Total	20,419	14,141	44,339	737.8	932.0	686.6

1 Energy Consumption and Electricity Generation are inconsistent.

2 Electricity is also purchased in small amounts from Shendi Textile and Maspio Cement.

Source: PEWC and NEA estimated

Electricity sales by the major economic activity of customers is presented in Table IV-17. This breakdown was made by NEA staff and Assessment team members in order to ensure consistency with similar categories of consumers in this Assessment. They differ from the records of the NEC in which tariff classes define consumer categories. The major adjustments consist of adding to agriculture and the commercial sector because the largest consumers in both these sectors purchase electricity at the industrial tariff rate.

b. Self-Generation

The electric self-generation sector in the Sudan is composed of a diverse group of institutions and consumers. the first distinction that has to be made is between isolated, primary (base load) generation (i.e., those systems not integrated with the NEC systems because of distance to the grid or unreliable commercial sources of electricity) and emergency or stand-by self-generation (i.e., back-up equipment for industries, commercial establishments, residences, etc.) The installed capacity of all non-NEC (excluding the sugar industry) sources amounted to over 110 MW in 1980 (Table IV-18 Self-Generation).

The largest non-NEC electricity generators are located in the industrial sector. This is particularly true in sugar industry where more than 68 MW of "actual" capacity (as opposed to 79.6 MW "rated" capacity), with 40 MW in Kenana alone, is found. All self-generated electricity in the sugar industry is derived from burning either bagasse or furnace oil. Over one-third, or 37,000 MT, of all furnace oil consumed in industry was consumed by the sugar sector in 1980. By comparison, the NEC consumed 43,000 MT of furnace oil in 1980.

Industrial self-generation outside the sugar subsector amounts to over 52 MW, of which 28 MW is found in the Khartoum area (and is mainly stand-by emergency generation) and 21 MW is located in the Red Sea Province (i.e., Port Sudan). Most of the latter operations serve as base load, primary generators due to the fact that NEC capacity in Port Sudan is inadequate to meet area demand. Milukas and Thorne (1981) provide an excellent review of industrial self-generation and should be referred to for more in-depth analysis.

Isolated public and private electric generation is found in small cities, towns and rural communities throughout Sudan. It is often the case that municipalities, urban and rural councils, rural cooperatives and small private companies generate electricity several hours a day and sell it to small group of customers. Given the dispersed nature of these sources of power supply, the small size of most generators, and the lack of centralized data available on these sources, it has only been possible to estimate from import statistics, reported observations and records of the local government councils, that at least 13.5 MW of actual capacity exists in this subsector. Actual capacity could be several megawatts greater than this figure.

In addition to the population served by the NEC and these non-NEC isolated systems, the communities in towns in which major industrial self-generating systems are located, such as sugar, textile and cement factories in areas isolated from the main grids, are often supplied by these factories.

TABLE IV-16

PEWC FUEL CONSUMPTION AND GENERATION: 1980

Region	Station	Fuel Consumption		Gasoil (Tonnes)	Electric Production GwH	Gwh Total
		Furnace	Diesel			
KHARTOUM	Burri	39,302	2,222	--	81.4	--
	Kilo X	39,302	2,222	6,321	12.0	--
CENTRAL	Wad Medani	175	114	--	1.1	--
	Roseires	--	--	--	619.8	--
	Sennar	--	--	--	97.2	--
	Ed Dueim	--	--	850	3.6	--
	El Geteina'	--	--	360	.4	--
	El Gorashi	--	--	480	2.1	--
	Central Sub-total	175	114	1,690	6.1	--
EASTERN	Port Sudan	--	8,405	--	35.0	--
	Khashm El Girba hydro	--	--	--	20.8	--
	Khashm El Girba diesel	--	574	--	1.1	--
	Kassala	--	318	1,429	6.0	--
	Eastern Sub-total	--	892	1,429	28.9	--
NORTHERN	Atabara	3,877	2,509	--	22.6	--
	Shendi[2]	--	--	1,327	4.1	--
	Dongola[3]	--	--	420	1.2	--
	Northern Sub-total	3,877	2,509	1,409	27.9	--
KORDOFAN	El Obeid[4]	985	--	1,190	6.2	--
	Um Ruaba[1]	--	--	980	3.1	--
	Kordofan Sub-total	985	--	2,170	9.3	--
DARFUR	El Fasher[1]	--	--	1,200	3.4	
	Nyala	--	--	1,080	4.4	
	Darfur Sub-total	--	--	2,280	7.8	--
SOUTHERN	Malakal[1]	--	--	1,080	.8	--
	Wau[1]	--	--	1,000	1.0	--
	Juba[1]	--	--	3,000	3.7	--
	Southern Sub-total	--	--	5,120	5.5	--
	Total PEWC	44,339	14,142	20,419	932.0	--

1. 79/80 figures
2. Electricity is also purchased from Shendi Textile and resold
3. Estimated; reported consumption of 82 tons is in-sufficient to generate the Gwh sold
4. Avg of 79/80 and 80/81 figures

TABLE IV-17

PEWC ELECTRICITY SALES 1980

Region \ Sector	Households	Government[1] +Commercial	Heavy Industry	Agriculture[2]	Services[3]	Total
Eastern	20.0	11.3	8.5	4.6	4.1	48.5
Northern	11.3	5.6	.4	1.8	3.5	22.6
Khartoum	190.3	35.8	114.5	15.3	19.1	375.0
Central	30.3	20.2	118.4	57.2	4.1	230.2
Southern	2.9	.2	--	--	1.4	4.5
Kordofan	4.0	1.5	--	--	.7	6.2
Darfur	2.7	1.1	.7	--	1.3	5.8
Total	261.5	75.7	242.5	78.9	34.2	692.8

1 Includes 21.6 Gwh of large customers from industrial tariff plus small industries

2 Includes 54.4 Gwh of large customers from industrial tariff; sugar included within industrial sector.

3 Street lighting, water pumping and utility use.

Source: PEWC and NEA estimates

TABLE IV-18

SELF-GENERATION CAPACITY[1]

REGION	SECTOR	ESTIMATED "ACTUAL" CAPACITY (MW)
EASTERN[1]		
	Sugar	4.70
	Private Industry	21.15
	Public Industry	5.40
CENTRAL		
	Sugar	63.42
	Private Industry	3.50
	Public Industry	4.10
KHARTOUM		
	Private Industry	28.00
	Public Industry	3.1
	Residential, Commercial, Diplomatic, etc.	10.40
KORDOFAN		
	Public Industry	2.40
DARFUR		
	Public Industry	2.00
NORTHERN		
	Public Industry	14.20
SOUTHERN		
	Public Industry	2.00
SUDAN SUB-TOTAL	Rural/Urban Councils, Coops, etc.[1]	13.50
SUDAN TOTAL SELF-GENERATION		177.91

[1] Because of lack of data, it is not presently possible to disaggregate total urban and rural council, cooperatives and other private self-generation in Sudan. Moreover, it has not been possible under the present project to estimate private residential self-generation in Port Sudan, although it may be as high as several megawatts installed capacity.

Private personal residential self-generation provides the last category of self-generation reviewed in this study. These are found primarily in Khartoum (and to a lesser extent in Port Sudan and other large urban areas) and are mainly used for stand-by or emergency self-generation. There is an estimated 10.4 MW of installed actual capacity in this category in Khartoum alone. These generators consumed an estimated 4,500 MT of gasoil (and smaller amounts of benzene) in 1980. The fuel use of these generators varies with the reliability of NEC supplies. This estimate of total installed capacity was made on the basis of direct observations during the course of the Assessment.

Finally, the total number of people in Sudan who enjoy electricity supplies in their homes from all sources (at least a few hours per day) could be as high as two million. This is dervied by applying average household sizes to the number of all residences served by the NEC and then applying a coefficient for the number of people served by all other isolated systems.

3. FORESTRY/WOODFUELS

Forestry resource surveys were conducted specifically for this assessment. This was necessary because previous studies, in the late 1950's and early 1960's, were based upon estimates made by experienced foresters and forestry advisors who did not have the benefits of extensive aerial photography, ground surveys or satellite imagery to draw upon. Jackson (1958, 1960) upon whom most estimates of forestry resources have been based over the past two decades, stated that his estimates of forestry volume (1.3 billion m^3 in 1960) could have been correct with a 50% margin of error. Forestry Administration and Project staff were strongly of the opinion that extensive changes had occurred in Sudan's forestry resource base since the early 1960's, and most particularly, over the past decade. This was felt especially to be the case in the Central and Eastern Regions of the country.

Therefore, the national Forestry Inventory Chief, Sayed Mohammed Hanafi Obeid worked for five weeks at the Regional Remote Sensing Facility (Nairobi) with satellite photographs and drew up an overall vegetation map for Sudan based on 1972-75 Landsat images. A composite vegetation map, divided into thirteen (13) strata and one sub-stratum (Table IV-19) was designed for those years covered. It was quickly seen by comparing this map with previous vegetation maps and later satellite images, that the Central and Eastern Provinces of Kassala, Blue Nile and White Nile had experienced extremely severe deforestation over the past two decades. Thus, the Project funded extensive ground surveys in these provinces during April and May, 1982. These surveys were conducted by teams of foresters and botanists from the Forestry Administration's Central Inventory Section, the University of Khartoum and the Forestry Research Institute at Soba. Roads and tracks were followed for sake of convenience and speed (to complete the surveys before the rainy season). It can be argued that this method of surveying (i.e., following established routes) resulted in some overestimations of forestry off-take, as these areas are most accessible for charcoal producers and others. These results can be, and should be, easily checked for accuracy through more extensive, better-funded and planned surveys. Nonetheless, every attempt was made, given constraints, to remove survey biases. Every 15 kilometers along the way, the teams would stop, trek one kilometer away

STRATUM	DEFINITION/DESCRIPTION
1	Closed canopy mountain forests: Appears very deep red on Landsat images. Associated with highlands, hills mountains. 80-100% crown cover.
2	Nearly-closed mountain forests: Appears red on on Landsat images. Associated with highlands. 60-80% crown cover.
3	High rainfall savanna forests: Appears Reddish brown on Landsat photographs. In area of 900-1,000mm annual rainfall. 50-60% crown cover.
4	Savanna woodlands: Annual rainfall between 600 and 950mm. 40-50% crown cover.
5	Low-rainfall savanna woodland: Annual rainfall between 400 and 600mm. 30-40% crown cover.
6	Bushlands: Annual rainfall approximately 400mm. Greater than 30% crown cover.
7	Riverian forest: Found along river drainage areas, "khors," and rivers. Generally not continuous, diffused.
8	Swampy vegetation: Found in large swampy areas with poor drainage, frequently standing water. Trees very water-tolerant.
9	Irrigated agricultural lands.
10	Mechanized rainfed agricultural lands: Characterized by very symmetrical patterns.
11	Shifting cultivation lands: Irregular shapes, changing from year to year.
12	Tall grasslands.
13	Grass with trees: Sparse vegetation usually scattered over areas of rough contours.
14	Forestry Administration plantations: Acacia Nilotica and Eucalyptus spp.

from the road or track (on both sides), and inventory all trees within a designated hectare. Trees were measured for girth; select trees were felled and their crown volumes were measured. These surveys resulted in the precise volume estimates seen for these three provinces in Table IV-20.

Total growing stock volume estimates for the remaining provinces in Sudan were derived from:

- Designation and area measurement of strata (and tree species found within each) from the composite satellite map and aerial photographs.

- Referring to previous surveys and studies, both recent and earlier, where volume estimates were made or where actual inventories were conducted. Such surveys included the ODA-financed inventories (1977-1979) of the Imatong Mountains Forest Reserve, Southern Region; Forestry Administration Management area surveys in the Blue Nile, Gezira, Khartoum, Kassala and White Nile Provinces; inventories conducted in areas of sawmill operations (Blue Nile, Bahr El-Ghazal, Western Equatoriam South Darfur, etc.); Hunting Technical Servcies' Jebel Marra (Dar Fur) surveys and inventories conducted since 1956; among others.

- Extensive ground expeience of foresters (both active and retired) with the Inventory Section, and in the Central Forestry Administration Headquarters.

- Interviews with Forestry Administration Conservators in Khartoum, Gezira, Upper and Lower Blue Nile, White Nile and Kassala Provinces as well as the Director of Forests in the Southern Region.

TABLE IV-20

FORESTRY/WOOD CONSUMPTION AND LOSS: 1980

CONSUMPTION/LOSS	WEIGHT '000 MT		GROWING STOCK VOLUME EQUIVALENT '000 m^3	
Firewood:(1) Total	8,312		24,937	
(Households)		7,830		23,490
(Commercial, Services, etc.)		259		778
(Industry)		223		669
Charcoal:(1) Total	2,585		46,527	
(Households)		2,449		44,082
(Commercial, Services, etc.)		136		2,445
Fire Losses(2)	250		750	
Over-Grazing(2)	290		870	
Mechanized Agri-Expansion(3)	363		1,090	
Traditional Shifting Cultivation(2)	220		660	
Other Causes(Bldg. Poles, Lumber, etc.)(2)	170		510	
Total Growing Stock Loss and Consumption(m^3)			75,344	

(1) NEA, Statistics Dept. Surveys
(2) NEA and Forestry Administration estimates.
(3) Land under mechanized cultivation increased by approximately 721,000 feddans(302,820 ha) in 1980/81. Assuming an estimated 4 m^3 growing stock hectare yields a growing stock loss of 1,211,280 m^3 or 403,760 MT for that year. Finally, assuming that 10% of the wood thus cleared for mechanized agriculture was used for charcoal and firewood (discussions with Forestry officials reveal that this is a very high estimate as most trees cleared for mechanized agriculture are merely burned in place) this yields an estimated loss due to mechanized agriculture of some 363,384 MT or approximately 1,090,152 m^3 in 1980.

Sources: Mechanized Farming Corp., NEA, Forestry Administration.

Second, while survey results show the Northern Regions of Sudan with a higher proportion of total national forestry resources (33% compared with the Southern Sudan 67%) than previously estimated (25% in the North and 75% in the South), they also show that the bulk of the North's resources (92%) are found in the two distant provinces of Southern Darfur and Southern Kordofan where less than 35% of the North's population lives. Thus, forestry resources are highly skewed in the North and, with increasing off-take in the central areas, increasingly inaccessible to ever-larger portions of the population.

Detailed analysis of tree species found in each stratum (see Forestry Resource Annex) show that increasingly inferior tree species (those providing less charcoal, less fodder, less soil protection) are found in the Central and Eastern Regions while volume per hectare of remaining species has dropped far below previous estimates. Again, Kassala, Blue Nile and White Nile Provinces show lowest volume per hectare and lowest yield per hectare of all "forested" provinces of the country (i.e., excluding N. Kordofan, N. Darfur, Red Sea, Nile and Northern Provinces, where desert and semi-desert conditions prevail).

Comparisons of Tables IV-20 and IV-21 illustrate that there is a marked annual national deficit annual allowable cut and fuelwood consumption/loss of approximately 31 million m^3 per year. Table IV-22 shows a national fuelwood deficit of some 23 million m^3, based only upon household (not services, industrial, etc.) consumption of some 77 million m^3. All northern provinces, except Southern Darfur, show marked household woodfuel deficits. All Southern provinces, with the exception of Eastern Equatoria (where the Southern Regional capital of Juba is located), show substantial woodfuel surpluses. The total Northern Sudan deficit was approximately 37.5 million m^3 in 1980, representing approximately 5.7% of total growing stock in the north. However, actual total consumption in 1980 (52.5 million m^3) represented a loss of over 8% of total growing stock in the North. However, as stated above, even this alarming statistics obscures the size of local (provincial and regional) deficits where total consumption is rapidly eliminating local resources. If present consumption/loss rates continue, all forested reas in the North will be denuded in twenty years.

4. OTHER RENEWABLES

Extensive attention to renewable resources in Sudan was paid by the NEA and the Project during the course of the Assessment. The NEA's Renewable Resource group (several of whom have now been seconded to the Institute of Energy Research to continue their work) worked closely with many experts at the National Council for Research, the University of Khartoum, various agencies, and private and public sector corporations and groups. One of the results of these efforts is an extensive Renewable Resources Assessment report recently published. In addition, two USAID-funded teams examined bio-resource potential and decentralized hydro-potential in Sudan and produced assessment reports which appear as Appendices V and VI of the main report.

Sudan's greatest non-forestry biomass resources, at present, are the bagasse and molasses produced as a by-product of sugar production. Sudan produced over 1 million MT of bagasse in 1980/81, of which only 430,000 MT, or roughly the equivalent of 140,000 MT of furnace oil, was used in the

industry's boilers for sugar processing and power generation. Were Sudan's cane production at design capacity, this quantity would be raised to over 2.0 million tonnes. Moreover, bagasse, if utilized efficiently, could reduce the sugar industry's present consumption of furnace oil (37,720 tonnes in 1980) to virtually zero. Molasses, most of which is currently wasted, could be utilized for ethanol production as well as provide a good, cheap additive for animal feed as illustrated in Table IV-23.

Few other renewable resources, with the exception of medium and large-scale hydropower and relatively small quantities of crop residues and animal wastes used for household cooking, are presently utilized for energy production in Sudan. However, there appears to be great potential for harnessing wind and solar energy, as well as some biomass resources such a groundnut shells and water hyacinths.

TABLE IV-21

FORESTRY RESOURCES IN SUDAN
BY PROVINCE AND REGION

REGION	PROVINCE	TOTAL AREA (HECTARES)	AVERAGE VOLUME (m^3/HECTARE)	TOTAL VOLUME (m^3)	ANNUAL ALLOWABLE CUT(m^3)
EASTERN[1]		2,748,065	2.55	7,007,855	234,602
	Red Sea	-	-	-	-
	Kassala	2,748,065	2.55	7,007,855	234,602
CENTRAL[1]		5,123,790	4.98	25,532,325	886,256
	B. Nile	4,957,440	4.90	24,313,794	831,198
	W. Nile	157,450	3.93	618,051	21,602
	Gezira	8,900	67.47	600,480	33,456
KHARTOUM[1]		5,000	60.00	300,000	30,000
KORDOFAN[1]		11,628,000	10.56	122,827,800	2,985,994
	S. Kordofan	11,628,000	10.56	122,827,800	2,985,994
	N. Kordofan	-	-	-	-
DARFUR[1]		17,693,300	26.97	477,199,800	9,587,083
	S. Darfur	17,693,300	26.97	477,199,800	9,587,083
	N. Darfur	-	-	-	-
NORTHERN[1]		-	-	-	-
	Northern	-	-	-	-
	Nile	-	-	-	-
Total Northern Region Scrub and Semi-Desert[1]		4,200,000	4.76	19,992,000	1,332,800
NORTHERN SUDAN SUB-TOTAL[1]		41,398,155	15.77	652,859,780	15,056,735
SOUTHERN		71,095,683	18.87	1,341,500,862	29,300,346
	Buhayrat	6,525,400	15.03	98,069,800	2,911,378
	Jonglei	11,863,900	3.76	44,643,700	2,097,915
	B. El-Ghazal	11,733,900	34.94	410,037,200	8,336,555
	E. Equatoria	10,818,150	18.18	196,632,396	4,328,640
	W. Equatoria	6,982,733	61.76	431,275,066	6,952,831
	Upper Nile	23,171,600	6.94	160,842,700	4,673,027
TOTAL SUDAN		112,493,838	17.73	1,994,360,642	44,357,081

1 Forestry Administration sources and Moh. El-Amin Mukhtar estimate the total area of desert and semi-desert scrub and brush wooded area at approximately 4,200,000 hectares, with a total growing stock of 19,992,000 m^3, an average growing stock volume per hectare of 4.76 m^3, and an annual allowable cut of approximately 1,332,800 m^3. These resources are scattered and are found primarily in Northern Kordofan and Darfur, Northern, Nile, Khartoum and Red Sea Provinces. Because of the inability to assign these resources to particular provinces, all estimates are included in both Northern Sudan sub-totals and in the estimate of Sudan's total forestry resources.

Source: NEA and Forestry Administration.

TABLE IV-22

HOUSEHOLD WOODFUELS BALANCE BY PROVINCE AND REGION[1]
(in '000 m^3 Growing Stock Equivalent)

REGION	PROVINCE	HOUSEHOLD CONSUMPTION	ANNUAL ALLOWABLE CUT	REGIONAL BALANCE
EASTERN		6,048	457	- 5,591
	Red Sea	1,419	-	
	Kassala	4,629	235	
CENTRAL		15,153	1,108	-14,045
	Blue Nile	4,059	831	
	White Nile	4,266	22	
	Gezira	6,828	33	
KHARTOUM		4,845	222	- 4,623
KORDOFAN		11,445	3,208	- 8,237
	S. Kordofan	5,463	2,986	
	N. Kordofan	5,982	-	
DARFUR		12,180	9,809	- 2,371
	S. Darfur	7,173	9,587	
	N. Darfur	5,007	-	
NORTHERN		2,829	222	- 2,607
	Northern	1,095	-	
	Nile	1,734	-	
NORTHERN SUDAN SUB-TOTAL		52,500	15,026	-37,474
SOUTHERN		15,072	29,301	+14,229
	El-Buhayrat	1,464	2,911	
	Jonglei	420	2,098	
	B. El-Ghazal	3,801	8,337	
	E. Equatoria	4,608	4,329	
	W. Equatoria	2,481	6,953	
	Upper Nile	2,298	4,673	
TOTAL SUDAN		67,572	44,327	-23,245

[1]Note: Estimates of total growing stock of desert and semi-desert scrub and bush for Northern Sudan yield a total volume estimate of 1,332,800m^3. For illustrative purposes and due to the impossibility, at present, of scientifically distributing this growing stock among the various provinces, one sixth of the total(i.e., 222,000m^3) is assigned to each northern region's total volume estimate. This figure would be higher in some regions(e.g., Kordofan and Darfur) and lower in other regions (e.g., Northern and Eastern).

Source: NEA, Forestry Administration and Statistics Dept.

TABLE IV-23

ANNUAL SUGAR, BAGASSE AND MOLASSES PRODUCTION IN SUDAN: 1978/79 - 1980/81

('000 MT)

PROCESS	El-Guneid			New Halfa			Sennar			Assalaya			Kenana			TOTAL		
	78/79	79/80	80/81	78/79	79/80	80/81	78/79	79/80	80/81	78/79	79/80	80/81	78/79	79/80	80/81	78/79	79/80	80/81
Sugar Production	36.54	29.69	35.85	64.85	43.05	50.00	18.19	39.00	32.00	-	7.67	12.60	-	24.40	91.80	119.6	143.8	222.3
Bagasse Production	203.4	143.4	179.3	311.1	217.4	252.0	104.8	173.8	180.0	-	42.7	63.0	-	122.0	459.0	619.3	699.3	1133.0
Molasses Production	13.30	11.00	14.80	24.22	20.55	22.80	9.06	18.36	19.60	-	3.50	6.28	-	11.09	41.73	46.58	64.50	105.2
DESIGN CAPACITY FOR SUGAR PRODUCTION	60			90			110			110			330			700		

Source: Sugar Corporation, Kenana Sugar Corp.

V. REGIONAL ENERGY BALANCES

The regional context in the Sudan is an important factor in all aspects of Sudan's present social, political and economic life. Size alone, one-third of that of the Continental U.S., makes the official concept of "regionalization" important. Added to that are ethnic and religious variety and climatological differences which result in wide ranges of economic activity. Superimposed over this geographical and socioeconomic dispersion is a wholly inadequate communications infrastructure which has a large impact on patterns of national energy consumption. Firewood and charcoal supplies (and prices) are strongly linked to regional factors. Supplies of petroleum products, in particular in times of shortages, are even more region specific with Port Sudan (port of the Eastern Region) having the easiest access to petroleum products, followed by Khartoum and the Central Region. At the other end of the spectrum, remote regions obtain their petroleum supplies with greater difficulty.

Throughout the previous chapters of this annex, information has been presented on a regional basis for most sectors of energy production and consumption. The intent in this chapter is to present an entire energy balance for each separate region. These balances contain all sectors of energy consumption and sources of supply in one summary table for each region. Tables V-1 through V-7 are balances prepared specifically for the Eastern, Northern Khartoum, Central, Southern, Kordofan and Darfur regions utilizing the same basic format at the National balances. The sources of the regional information have been explained in Chapter III. Regional breakdown of the data for agriculture and industry derive directly from the geographical location of the users in each region. Information on NEC and commercial and government users is similarly derived. The regional breakdowns for households are based on the survey work as explained in section III.1.

Breakdowns are further complemented by demographic data and information on fuel availability. The regional breakdowns for road transportation weere made on the basis of regional sales of benzine and gasoil at retail stations as reported by the petroleum distribution companies and the GPC.

A few exceptions to a complete regional allocation of energy consumption were considered relevant. For several transportation modes that link two or more regions together, it was considered impractical to allocate fuel consumption among the regions. Thus, fuel use by Sudan's railway, river boats, pipeline and airplanes was omitted from the regional allocation and is presented separately in Table V-8. Also included in Table V-8 is the fuel use by construction firms who are principally involved in building roads that link two or more regions. A final category of fuel consumption that has not been broken down by region is that of stand-by electric generators. In this instance the allocation by region was not completed because of lack of data.

The diversity in patterns of energy consumption are shown in Table V-9, which indicate that whereas 54% of the Khartoum region energy consumption is met by petroleum products, this ratio for the Southern region is only 1% (although this excludes the oil that reaches the Southern Region from Kenya, for which no information was obtained). Large variation is also present in the consumption of traditional energy products, in many ways a more valid comparison of the disparity of resource base and household energy use patterns than imported petroleum, which is much more an indicator of the level of development of the modern sector of the

TABLE V-1

TOTAL ENERGY CONSUMPTION 1980 EASTERN REGION

(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	--	*	--	--	13,358	8,213	--	17,400	--	732
2. Agriculture	--	--	--	--	25,480	--	--	--	--	--	--	396
3. Transport	--	26,880	--	--	47,112+	--	+	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	746+	--	--	5,713	15,228	--	--	1,326
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	485	6,032	4,160+	--	--	265,740	167,760	24,430	--	1,722
7. NEC Electricity Generation	1,791	--	--	--	1,486	9,483	--	--	--	--	--	--
Total	1,791	26,880	485	6,032+	78,984+	9,483	13,358+	279,666	182,988	41,830	--	4,176

* Less than 300 tons
\+ Additional Fuel Consumption included on Table 8: Remainder - All Regions

TABLE V-2

TOTAL ENERGY CONSUMPTION - NORTHERN REGION 1980
(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	--	*	1,664	5,093	14,706	7,740	--	--	--	34
2. Agriculture	--	--	--	--	9,256	--	--	--	--	--	--	155
3. Transport	--	5,250	--	+	19,240+	--	+	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	658+	--	--	4,725	9,461	--	--	748
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	42	1144	2,392+	--	--	77,830	91,440	22,670	--	973
7. NEC Electricity Generation	--	--	--	--	1,465	2,559	3,722	--	--	--	--	--
Total	--	5,250	42	1144+	34,675+	7,652	18,428+	90,295	100,901	22,670	--	1,910

* Less than 300 tons
\+ Additional Fuel Consumption included on Table 8: Remainder - All Regions

TABLE V-3

TOTAL ENERGY CONSUMPTION 1980 - KHARTOUM REGION
(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	*	*	8,840	889	23,494	29,326	--	--	--	9,861
2. Agriculture	--	--	--	--	728	--	--	--	--	--	--	1,318
3. Transport	--	133,980	--	+	116,064+	--	--	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	160+	--	--	3,179	10,908	--	--	4,728
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	4,155	4,680	2,600+	--	--	75,250	172,800	--	--	16,389
7. NEC Electricity Generation	--	--	--	--	6,571	2,266	37,730	--	--	--	--	--
Total	--	133,980	4,155	4,680	134,963+	3,155	61,224+	107,755	183,708	--	--	32,296

* Less than 300 tons
+ Additional Fuel Consumption included on Table 8: Remainder - All Regions Unknown and possibly significant

TABLE V-4

TOTAL ENERGY CONSUMPTION 1980 - CENTRAL REGION

(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	--	*	10,400	408	48,366	18,146	--	68,600	--	10,197
2. Agriculture	--	--	--	--	48,672	--	--	--	--	--	--	4,926
3. Transport	--	25,515	--	+	61,413	--	+	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	3,914+	--	--	9,322	16,826	--	--	2,093
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	35	3,224	8,736+	--	--	647,150	425,520	154,400	8,500	2,609
7. NEC Electricity Generation	61,748	--	--	--	1,758	116	168	--	--	--	--	--
Total	61,748	25,515	35	3,224+	134,893+	524	48,534+	674,618	442,346	223,000	8,500	19,825

* Less than 300 tons
\+ Additional Fuel Consumption included on Table 8: Remainder - All Regions

TABLE V-5

TOTAL ENERGY CONSUMPTION 1980 - SOUTHERN REGION

(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	--	--	*	--	--	9,933	--	--	--	--
2. Agriculture	--	--	--	--	3,744	--	--	--	--	--	--	--
3. Transport	--	3,255	--	--	8,744	--	--	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	+	--	--	36,599	11,966	--	--	138
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	--	+	1,352+	--	--	1,223,780	261,360	201,330	--	388
7. PEWC Electricity Generation	--	--	--	--	2,280	--	--	--	--	--	--	--
Total	--	3,255	--	+	16,120+	--	--	1,270,312	273,326	201,330	--	526
Imports From Kenya	--	5,000	--	2,500[2]	10,000[3]	--	--	--	--	--	--	--

* Less than 300 tons

\+ Additional Fuel Consumption included on Table 8: Remainder - All Regions
Mobil, Caltex, Shell, Total and Agin all solid fuel to Southern Sudan. Figures quoted here are rough estimates based on interviews in Nairobi with Mobil in July 1982 and Caltex and Shell in July 1981.

2 Largely jet fuel

3 Assumed to be primarily used in transportation and generators. Largest customers are international aid agencies.

TABLE V-6

TOTAL ENERGY CONSUMPTION 1980 - KORDOFAN REGION
(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	--	--	1,352	--	233	15,179	--	4,740	--	--
2. Agriculture	--	--	--	--	3,848	--	--	--	--	--	--	--
3. Transport	--	4,200	--	+	10,847+	--	+	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	1,293+	--	--	28,567	19,181	--	--	189
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	--	1,560	4,784+	--	--	505,250	316,800	1	--	344
7. PEWC Electricity Generation	--	--	--	--	2,257	--	946	--	--	--	--	--
Total	--	4,200	--	1,560+	24,381	--	1,179+	548,996	335,981	4,740	--	533

+ Additional Fuel Consumption included on Table 8: Remainder - All Regions

l Unknown and possibly significant

TABLE V-7

TOTAL ENERGY CONSUMPTION 1980 - DARFUR REGION
(TOE)

Fuel Sector	Hydro Power	Benzine/ Avgas	LPG	Kerosene Jet Fuel	Gasoil	Diesel	Furnace Oil	Wood	Charcoal	Other Bio-Mass	Vegetable Oil	Purchased Electricity
1. Industry	--	--	--	--	624	--	--	7,330	--	3,780	--	30
2. Agriculture	--	--	--	--	2,808	--	--	--	--	--	--	--
3. Transport	--	1,575	--	--	9,693+	--	+	--	--	--	--	--
4. Commercial Government Services	--	--	--	--	1,222+	--	--	23,412	14,213	--	--	207
5. Construction Oil Exploration	--	--	--	--	+	--	--	--	--	--	--	--
6. Households	--	--	--	882	3,432	--	--	571,900	327,600	1	--	233
7. PEWC Electricity Generation	--	--	--	--	2,371	--	--	--	--	--	--	--
TOTAL	--	1,575	--	882+	20,150+	--	+	602,642	341,813	3,781	--	500

+ Additional Fuel Consumption included on Table 8: Remainder - All Regions

1 Unknown and possibly significant

TABLE V-8

ENERGY CONSUMPTION 1980 - REMAINDER - ALL REGIONS

TOE

Fuel Sector	Avgas	LPG	Kerosene & Jet Fuel	Gasoil	Furnace Oil
Rail Transport	--	--	--	27,664	21,024
River Transport	--	--	--	2,392	--
Air Transport	6,300	--	46,384	--	--
Pipeline	--	--	--	2,808	--
Commercial Generators	--	--	--	832	--
Household Generators	--	--	--	4,680	--
Construction & Oil Exploration	--	--	--	34,320	--
Industry	--	800	--	--	--
TOTAL	6,300	800	46,384	72,696	21,024

TABLE V-9

SUMMARY OF ENERGY RESOURCES CONSUMED BY REGION
(TOE)

Region	Hydro	Petroleum Products	Wood	Charcoal	Other Biomass	Purchased Electricity	Total
Eastern	1,791	153,734	279,666	182,988	41,830	(4,176)	660,009
Northern	0	67,191	90,295	100,901	22,670	(1,946)	281,057
Khartoum	0	342,160	107,755	183,708	--	(32,296)	633,623
Central	61,748	212,725	647,618	442,346	231,500	(19,825)	1,595,937
Southern	0	19,375	1,270,312	273,326	201,330	(388)	1,764,343
Kordofan	0	31,320	548,996	335,981	4,740	(533)	921,037
Darfur	0	22,607	602,642	341,813	3,780	(500)	970,842

economy. Charcoal represents 36% of total energy use in the Northern region, and similar percentages in the Western Regions (Darfur and Kordofan), while it is only 15% in the Southern Region. This disparity is a result of local availability of firewood in the South whereas there in the North and West woodfuel has to be transported longer distances and therefore is first converted to charcoal.

CHAPTER VI. ENERGY DEMAND PROJECTION METHODOLOGY

1. GENERAL APPROACH

This section outlines the methodology employed in generating projections of energy demand to the year 1990. The purpose is to tabulate all parameters such as coefficients of energy use per unit of output, and the economic output levels (such as feddans under cultivation or tonnes of cement produced) that are the principal driving factors of future energy demand.

It is clear, however, that it is not possible to generate purely "demand driven" energy demand projections for the Sudan. Firstly, the levels of energy consumption in 1980, our base year, are distorted by supply considerations and are far from reflecting true energy demand that year. Secondly, this situation is not likely to change soon, that is, at least not before 1986 when domestic oil production will relieve the largest pressures on the foreign exchange required to import all the crude and petroleum products needed by the economy. Availability of vastly improved petroleum supplies after 1986 will still depend, however, on factors quite apart from the new foreign exchange obtained from crude exports: the fuel transport infrastructure will have to be improved, storage tanks for special products such as LPG will have to be built, etc. Lastly, any "most likely" view of future petroleum use levels in the Sudan has to take into account the plans of GPC who for certain fuels, in particular kerosene and LPG, determines production levels on other than purely market considerations.

The approach outlined here is therefore a combination of "demand driven" calculation on the one hand, and estimates of future levels of consumption based on supply considerations on the other. In general, fuel use for the productive sectors of the economy, particularly agriculture, industry and freight transport, is projected on the basis of demand considerations only, while energy use for discretionary purposes, such as passenger transport and household fuels, is projected with other than purely demand consideration ignores electricity demand based on household or other sectors' needs; fuel requirements for the NEC are calculated on the basis of a realistic look at the existing expansion plans.

The following section covers the macro-economic growth rates that serve as a basis for the energy demand projections. That is followed by sections that cover the methodology for the projection for agriculture, industry, transportation, commercial/services, households and electric generation.

2. MACRO-ECONOMIC PROJECTIONS

In projecting levels of future energy consumption, a number of implicit assumptions about the interaction between energy use and the economy have to be made. The economic projections prepared for purposes of the energy projections are not intended as independent forecasts of economic activity. Instead, they draw heavily from two types of sources.

- existing projections made by organizations such as the Ministry of Planning, the Ministry of Finance, the Bank of Sudan, the World Bank and others.

- specific investment plans and scheduled production levels from both public and private enterprises.

A combination of these two types of information sources yielded a number of inconsistencies which have been resolved using our best judgement. These inconsistencies appear sharpest in the industrial sector. The World Bank projections show the industrial sector growing at 3.5% p.a. to 1984 and slightly higher later in the decade to reach 5.0% p.a. growth by 1991-1992. The information collected at the plant level indicate that a significantly higher growth will be realized, which is both necessary for the financial viability of the sector and consistent with the foreign exchange position to which the Sudan must adhere. This is because the planned growth is in import-substitution industries, i.e. cement, sugar, textiles, fertilizer, etc. The indications that such a growth will be realized are many: capacity expansion projects that are underway, increased land under cultivation in the case of sugar, and the gradual completion of Power III projects which will reduce electricity outages and increase output in the textile sector. The overall growth rate for industry is therefore estimated to be about 11% p.a. to 1986, followed by a gradual decline to the levels indicated by the World Bank from 1989 on.

With this major exception, the macro-economic projections used have been those prepared by the World Bank. These are shown in Table VI-1. For agriculture the reliance on World Bank data has been complete, both for feddans (as well be seen in the next section) and total output. Finally, the growth in "other sectors (commerce, services, utilities, transport) largely follows the World Bank growth in order to obtain the aggregate overall GDP growth. In terms of the energy projections, however, these indicators are less relevant, because two important components, transport and electric utilities, have been projected separately. For transport energy demand, as is detailed in a separate section, a combination of factors are considered such as growth is agricultural output and levels of fuel availability. Energy demand by the electric utility grows in line with Power III and tentative Power IV plans, as detailed in the final section.

3. AGRICULTURE

This sector consumes gasoil for irrigation and for agricultural operations, as well as electricity for water pumping and fuels for transportation of products. Only the future gasoil for irrigation and agricultural operations is projected here.

The calculation is based on future number of feddans under cultivation for each crop each mode of cultivation. The World Bank has been used as source for these projections for cotton, dura, groundnuts, sesame, wheat and millet

TABLE VI-1

WORLD BANK GDP GROWTH PROJECTIONS
(LS MILLIONS)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Industry	366.98	379.82	393.12	408.43	428.20	442.2	459.89	478.29	497.42	522.29	548.41
Growth	-	1.035	1.035	1.039	1.04	1.04	1.04	1.04	1.04	1.05	1.05
Agric.	986.2	1010.86	1041.18	1077.62	1120.73	1165.56	1218.0	1272.82	1336.46	1403.28	1473.44
Growth	-	1.025	1.030	1.035	1.04	1.04	1.045	1.045	1.05	1.05	1.05
Other	1262.4	1281.34	1306.96	1339.64	1379.63	1428.12	1478.11	1537.23	1598.72	1662.67	1729.17
Growth	-	1.015	1.02	1.025	1.0299	1.0351	1.035	1.04	1.04	1.04	1.04
GDP	2877.14	2939.22	3015.39	3108.71	3218.33	3339.87	3471.60	3617.7	3775.86	3947.06	4126.13
Growth	1.0172	1.0216	1.0259	1.0309	1.0353	1.0376	1.0396	1.0421	1.0437	1.0453	1.0454

Average GDP Growth 1982-1990 = 1.0326

Source: World Bank

(Table VI-2). The World Bank projections refer to all feddans under cultivation, that is, without regard to cultivation types (mechanized versus traditional, etc.). It is therefore necessary to calculate coefficients of average gasoil use per feddan per crop where the denominator is consistent with the amount of feddans projected by the World Bank. Note that in Chapter III, Tables III-14 and III-22, fuel consumption rates are given on the basis of, for example, gallons per feddan irrigated by gasoil (i.e., not all irrigated feddans which include electric pumps also), which is why those coefficients are significantly higher. The fuel use rates used for the purposes of the agriculture sector projections are shown in Table VI-3.

TABLE VI-2

PROJECTED FEDDANS UNDER CULTIVATION[1], 1983-1991
(1000 feddans)

	1983	1984	1985	1986	1987	1988	1989	1990	1991
Cotton	985	1035	1080	1085	1130	1145	1160	1175	1185
Dura, irrigated	634	659	674	679	689	689	689	689	689
Dura, mechanized rainfed	6134	6259	6374	6479	6589	6689	6789	6889	7089
Groundnuts[2]	407	437	451	465	470	470	470	470	470
Sesame	450	450	450	450	450	450	450	450	450
Wheat	349	372	392	412	432	442	452	452	452
Millet	2700	2800	2800	2800	2800	2900	2900	3000	3000
Sugarcane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Perennials	NA	NA	NA	NA	NA	NA	NA	NA	NA
Annuals	NA	NA	NA	NA	NA	NA	NA	NA	NA

[1] Includes all types of irrigated feddans (gravity fe, electric and gass oil pumps).

[2] The traditional cultivation sector is not included.

Source: World Bank, with the exception of sugarcane, perennials and annuals.

TABLE VI-3

FUEL USE COEFFICIENTS IN 1980[1]

	Gasoil used in Irrigation gals/feddan	Gasoil used in Agric. Operations gals/feddan
Cotton	1.36	3.89
Dura	1.30[a]	2.00[b]
Groundnuts	0.02[c]	3.06
Sesame	0	1.28
Wheat	0.18	2.66
Millet	0	0
Sugarcane	0[d]	20.0[e]
Perennials	NA	NA
Annuals	NA	NA

[1] Calculated for each crop as the sum (for all schemes) of gasoil used divided by the sum of all feddans under cultivation (except where noted).

a Coefficient calculated on the basis of irrigated feddans only.

b Coefficient calculated on the basis of mechanized rainfed feddans only.

c Coefficient is low because most irrigated feddans use electric pumps.

d Irrigation is all electric.

e Coefficient is based in data for Kenana only; havesting in most other plantations is not mechanized.

Demand for gas oil in future years is obtained by multiplying the projected feddans under cultivation by the respective coefficient of fuel use per feddan. These coefficients are assumed to stay constant throughout the projection years.

It is important to note that agricultural yield is projected by the World Bank to increase substantially, that is, production grows at a faster rate than feddans under cultivation (see Table VI-3). The consumption of fuel in agricultural operations is more closely related to total area cultivated and is relatively independent of total production. The transportation of crops is directly linked to total production, however, and the projected growth in agricultural output is utilized in the projection of fuels for transportation as shown in the section below.

TABLE VI-4

AGRICULTURAL PRODUCTION, ALL CULTIVATION TYPES 1981-1990

(000 tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Cotton	284	387	427	486	592	631	713	756	805	847
Groundnuts	706	1059	893	963	1077	1091	1145	1173	1253	1294
Sorghum/Dura	2109	2905	2892	2992	3186	3343	3470	3618	3754	3821
Sesame	211	258	229	243	253	267	284	296	312	312
Millet	481	573	572	594	602	638	638	638	638	660
Wheat	218	182	161	177	186	214	227	232	272	272
Rice	12	0	0	0	0	0	0	0	0	0
TOTAL	4021	5364	5174	5465	5888	6305	6431	6713	7034	7206

Source: World Bank

4. Transportation

The 1980 data base for the transportion sector examines freight and passenger transportation modes and tabulates total ton-km, pass-km, fuel use rates (grams of fuel per pass-km or ton-km), and total fuel use is obtained by multiplying levels of activity (ton-km or pass-km) by fuel use rates.

The first step in the projection is to obtain a growth rate for total pass-km and a growth rate for total ton-km. Next, the distribution of total ton-km or pass-km among the different modes is made. the third step is to estimate fuel use rates, which will be either similar to those obtained for 1980 or lower if average fuel efficiency are estimated will improve.

a. Freight:

In order to project total ton-km, it has been estimated that 25% of total ton-km are related to agricultural exports and that 75% are related to other goods. Therefore, the overall growth rate for total ton-km is a weighted average between the growth rate of the principal agricultural exports (11.0% p.a. for 1980-81 and 5.1% p.a. for 1985-1990, World Bank estimates of cotton and groundnuts production), and the growth rate of GDP (2.6% p.a. to 1985, 3.97% p.a. to 1990, EDI estimates).

For 1985:

$$7.5 \times 10^9 \text{Ton-KM} \times 0.25 \times 1.11^5 + 7.5 \times 10^9 \text{Ton-KM} \times 0.75 \times 1.026^5 = 9.6 \times 10^9 \text{Ton-KM}$$

For 1990:

$$9.6 \times 10^9 \text{Ton-KM} \times 0.25 \times 1.051^5 + 9.6 \times 0.75 \times 1.0397^5 = 11.8 \times 10^9 \text{Ton-KM}$$

Table VI-4 shows the projected breakdown by mode.

A trend towards a greater participation of truck is predicted; ton-km for rail and river transport are obtained from the Min. of Planning and Transport: Impact of Domestic Production on the Transport Sector in Sudan.

Table VI-4 also shows changes in fuel use rate. The fuel use rate for railroad corresponds to that of diesel engines, assuming that all steam locomotives are phased out completely by 1985 as planned. For medium-sized truck an improvement in fuel efficiency from 48 gm/ton-km to 40 gm/ton-km is assumed, to account for a higher percentage of travel over surfaced roads in the future.

The final columns on Table VI-5 show the projected amounts of gasoil used by each mode. They are the result of multiplying ton-km by the fuel use rate.

Table VI-5

FREIGHT TRANSPORT PROJECTION

	PROJECTED TON-KM (10^9)			FUEL USE RATE	PROJECTED FUEL DEMAND (000 TON) GASOIL	
	1980	1985	1990	GMS/TON-KM	1985	1990
RAIL	1.91	2.0	2.1	10	20.0	21.0
RIVER	0.05	0.1	0.3	35	3.5	10.0
PIPELINE	0.3	0.3	0.3	9	2.7	2.7
HEAVY TRUCKS	1.60	2.4	3.3	22	52.8	72.6
MEDIUM TRUCKS	3.64	4.8	5.8	40	192.0	232.0
	7.50	9.6	11.8		271.0	338.3

b. Passenger:

The first step in the projection also involves total pass-km. In this case, the growth rate in overall passenger km is obtained less from underlying economic growth parameters than from prognoses of future supplies. Passenger transport is primarily a discretionary use of energy, in particular that of private automobiles. For purposes of these projections a growth rate of total pass km of 5% p.a. was selected. This corresponds to GPC's planning for increases in benzene supply, the majority of the fuel used in passenger transport.

The next step is to distribute the total pass-km by mode. Those for rail, river and air (domestic) are obtained from the Ministry of National Planning. Total pass-km for intercity buses is given a low growth rate, and the remainder is assumed to be taken up by "other" passenger transport which includes private autos, taxis, "boxes" and minibuses. This latter group is known to be growing the fastest, in particular minibuses and private autos. Table VI-6 shows the resulting pass-km for 1985 and 1990.

Table VI-6

PASSENGER TRANSPORT PROJECTION

	PROJECTED TON-KM (10^9)			FUEL USE RATE	FUEL DEMAND (000 TONNES)		
	1980	1985	1990	GMS/TON-KM	1985	1990	FUEL
BUS	5.58	6.0	6.5	7.5	45.0	52.5	Gasoil
OTHER PASS	6.86	9.9	13.2	25.0	247.5	330.0	Benzine
RAIL	1.03	1.3	1.8	4.4	5.7	7.9	Gasoil
RIVER	0.06	0.1	0.2	7.5	0.8	1.5	Gasoil
AIR (DOMESTIC[1])	0.75	0.9	1.5	31.4	(28.3)	(47.1)	Kerojet[2]
	14.28	18.2	23.2		299.0	391.9	

1 Excluded from summation of total fuel demand

2 Demand for Kerojet is projected to grow at about 6.0% p.a. for both domestic and international use.

The passenger transport projection is greatly influenced by the GPC projection of future benzine supply. Vehicle registrations have been increasing at more than 10% p.a. which should manifest itself in a similar growth rate for benzine. In fact, benzine supplies have been severely restricted and rationed and the historical benzine consumption trend is clearly not an accurate measure of demand. Moreover, by 1982 the Government had also restricted importation of passenger vehicles. It is therefore important to monitor developments that have an impact on passenger transport, such as Government action on prices and import regulations, and GPC decisions on supply of benzine.

The final step is calculating fuel demand by multiplying pass-km by the fuel use rate. Note that, as shown in the last column in Table VI-5, different passenger modes consume different fuels.

5. Industry

Fuel demand in industry is projected on the basis of future production (in tonnes) multiplied by fuel use per unit of production. Unit fuel demand is obtained from the 1980 data base collected at the NEA, modified to incorporate increases in industry capacity factors where appropriate.

The projection is based on four existing industries (cement, textiles, sugar and edible oils/soap), two new industries (fertilizer and bitumen) and two traditional industries (bakeries and brickmaking). The remainder is grouped into a miscellaneous category as indicated in the 1980 energy balance (see table III-28). It is clear that as the historical data base gets expanded, more industries could be analyzed separately. More accurate fuel demand projection would thus be obtained, since the miscellaneous category is projected simply on the basis of a growth rate related to the growth rate of the industrial component of GDP.

a. Cement:

The Maspio cement plant is adding 236,000 tonnes of capacity to be completed in 1983. Total production in 1985 is obtained by assuming that the new expansion will operate at 75% of capacity and that the existing (1982) plants produce about 190,000 tonnes, 10% more than in 1980 (and still at about 58% of capacity). Furthermore, production is assumed to stay constant to the end of the decade: projects such as Derudeb (500,000 tonnes), Marsa Arkayi (1 million tonnes) and Kapoeta are not included.

Several reports on the industry and available in NEA files: Memo, UNIDO report on Rabak, and LA Nilsen: The Sudanese Cement Industry (1980).

Table VI-7 shows the fuel demand projections for the cement industry.

Table VI-7
Cement Industry Projection

	1980	1985	1990
Production (tonnes)	173,000	370,000	370,000
Fuel Use Rate (tonnes/tonne)			
Furnace Oil	0.11	0.10	0.10
Diesel Oil	0.02	0.035[1]	0.03
Gas Oil	NA	NA	NA
Fuel Demand (tonnes)			
Furnace Oil	19,724	37,000	37,000
Diesel Oil	3,431	12,950	11,100
Gas Oil	927	1,000	1,000

[1] Includes diesel used for generation of excess electricity to be sold to the NEC.

b. Sugar:

The design capacity of the sugar sector in the Sudan is about 640,000 tonnes, of which 330,000 tonnes belong to the new Kenana plant. The four older plants, whose total production was only 133,000 tonnes in 1980, are assumed to improve their output to some 220,000 tonnes by the mid 1980's. Kenana is assumed to reach 180,000 tonnes in 1985 and 280,000 tonnes in 1990. Total production, as shown in Table VI-8, is 400,000 tonnes in 1985 and 500,000 tonnes in 1990.

The use of furnace oil per tonne of sugar for the industry as a whole in 1980 was 0.29 tonnes/tonne of sugar, an extremely high usage. Consumption at Guneid and Sennar was only 0.07 tonnes/tonne that year, very close to average in other countries. Ultimately, sugar mills could be operated exclusively on bagasse without any furnace oil. Therefore, furnace oil use rate was decreased in the projection to an average of 0.12 tonnes/tonne by 1990, as shown in Table VI-8.

It would be useful to be able to account for the use of gasoil in the sugar industry. The data base could be expanded in order to identify gasoil uses in the mill and refining process, in electric generation, in agricultural operations and in transport. This is to avoid double counting with other sectors especially agriculture and transport.

Table VI-8

SUGAR INDUSTRY PROJECTION

	1980	1985	1990
Production (tonnes)	130,400	400,000	500,000
Fuel Use Rates (tonnes/tonne of Sugar)			
Furnace Oil	0.290	0.164[1]	0.120[1]
Gas Oil	0.087	0.087	0.087
Bagasse	0.72[2]	0.72[2]	0.72[1]
Fuel Demand			
Furnace Oil (tonnes)	37,720	65,600	60,000
Gas Oil (tonnes)	11,300	34,800	43,500
Bagasse (tonnes)	94,500	288,000	360,000

1 See text

2 Represent 0.72 toe of bagasse, where 1 toe = 5 Tonnes Between 30 - 40% of the weight of sugarcane is produced as bagasse, and about 10% is sugar.

c. Textile:

The output of the textile sector has declined to some 83 million yards in 1980 from levels two times higher earlier in the decade. Several factors contribute to the low capacity factor, and they are likely to persist. Production is projected to be 135,000 tonnes in 1985 and 154,000 tonnes in 1990.

The textile industry presents difficult aggregation products because it produces a variety of products whose outputs are measured in tonnes and in yards. It is therefore important to ensure that the aggregate fuel consumption tabulated for 1980 is consistent with the volume of output measured for that year (i.e. number of yards). it is also not possible to define fuel use rates per unit of output when the output consists of a variety of products. As is explained in Table VI-9 a slightly different methodology is used.

Table VI-9

TEXTILE INDUSTRY PROJECTION

	1980	1985	1990
Production (10^6 yards)	83	135	154
Fuel Utilization (tonnes)			
Furnace Oil[1]	14,058	18,600	21,200
Gasoil[2]	10,064	8,500	8,500

[1] Furnace oil demand grows at about one half the rate of growth of output, on account of the low capacity factors and the diseconomies in energy demand resulting from low capacity. See Table III-26; the factors in this Table have not been used exactly as shown, since they refer to all energy (including electricity), and not to furnace oil in particular.

[2] Assumed to decrease from 1980 levels due to less of emergency generators as new power plants come on line in the Blue Nile grid.

d. Oil and Soap:

This industry is composed of two segments. First is the oil press sector in which groundnuts are processed into oils, oilcakes and animal feed. Current production is about 0.5 million tonnes, and capacity is estimated to be 1.0 million. The industry has undergone large changes, with cottonseed, castorseed and sesame seeds being replaced by peanuts grown in Western Sudan, one of the fastest growing segments of Sudanese industry.

Production of edible oils and soap amounts to 80,000 tonnes and 50,000 tonnes respectively. This sector is projected to grow at 3.0% p.a. to 1985, and at 3.5% p.a. for 1985-1990. Production will grow slowly in part because some of the raw materials required are imported and are therefore under the same foreign exchange pressures as the rest of the economy.

Table VI-10 shows the projection of fuel demand for this sector.

Table VI-10

OILS AND SOAP INDUSTRY PROJECTION

	1980	1985	1990
Oils and Soap (tonnes)	130,000	151,000	179,000
Fuel Demand			
Gas Oil (tonnes)	5,309	6,166	7,310
Diesel (tonnes)	132	153	182
Furnace Oil (tonnes)	19,479	22,625	26,821
Oil Presses (tonnes)			
Fuel Demand			
Wood (tonnes)	29,600	44,400	59,200
Crop Residues (tonnes)	42,500	63,000	85,000

e. New Manufactures:

Bitumen Plant: A 40-60,000 tonne capacity bitumen plant will be constructed by 1985. Its fuel demand of 36,000-54,900 tonnes of furnace oil and 3470-5200 tonnes of kerosene has been incorporated into the projections.

Fertilizer Plant: The In-ran fertilizer plant is being constructed. At capacity it will consume 120,000 barrels of gasoil (16,500 tonnes) and 150,000 tonnes of naphtha. Assuming it produces at 70% plant capacity i.e., 11,550 tonnes gasoil and 105,000 tonnes of naphtha are added to the projection for 1985 and 1990.

f. Brickmaking & Bakeries:

Consumption in these Industries is assumed to grow at the rate of growth of population 2.8 percent per year gasoil consumption by bakeries grows at the rate of growth of urban population (30 percent per year used until the correct rate is estimated).

g. Miscellaneous:

The fuel consumption of the rest of the industrial sector fuel consumption is made to grow at the rate of growth of the Industry share of GDP as shown in section 2 of this chapter. As indicated earlier, an expansion of the 1980 data base that identifies more segments of the industrial sector separately would improve the methodology, and make this miscellaneous category be linked to a much smaller fraction of total industrial fuel consumption.

6. Commercial, Government Services, Construction and Oil Exploration

Several unrelated activities that consume significant amounts of energy have been grouped in one category. Each of these have been projected separately, however, based on available indicators. The summary projection is shown in Table VI-11.

a. Road Construction: Approximately an average of 160 Km of new roads are scheduled to be completed every year during the next decade. Relative to road comp ·ion in the base year 1980,it indicates a consumption of 27,000 tonnes per yea· versus 23,000 in 1980.

b. Petroleum Exploration: Chevron's plans indicate a need of gasoil to be served by the 400 bbl/day (20,000 tonnes per year) output of gasoil from a small topping plant. Actual gasoil use for oil exploration has been therefore assumed to be 15,000 tonnes in 1985, decreasing to 12,000 in 1990.

c. Commercial Buildings: Consumption of gasoil in emergency generators is kept at the 1980 level for the entire decade.

d. Government Services/Municipal Water Pumping: Gasoil demand grows at the rate of population 2.8% p.a.

e. Eating Places, Laundries: Charcoal demand is projected to grow at the rate of growth of urban population 3.9% p.a.

Table VI-11

Government, Commercial and Services Projection

	1980		1985		1990	
	Gas Oil (Tonnes)	Wood & Charcoal (Toe)	Gas Oil (Tonnes)	Wood & Charcoal (TOE)	Gas Oil (Tonnes)	Wood & Charcoal (TOE)
Petroleum Exploration	10,000	-	15,000	-	12,000	-
Road Construction	23,000	-	27,000	-	27,000	-
Buildings	800	-	800	-	800	-
Eating Places, Laundries	--	165,000	--	199,000	--	241,000
Water Pumping	8,000	-	9,184	-	10,554	-
	41,800	165,000	51,984	199,000	50,354	241,000

7. Households

The household energy demand projections have been elaborated in a simple straightforward manner, by applying a growth rate to historical levels of consumption. These growth rates are shown in Table VI-12.

For the case of kerosene and LPG, the projections are a reflection of growth in available supplies provided by the GPC. The use of gasoil would thus decrease with renewed availability of kerosene. The growth rates for charcoal, firewood, crop residues, etc. are more tentative, and it will be worthwhile to review them once the household survey data is all analysed. For example, regional urban and rural population growth rates could be applied to regional patterns of cooking fuel usage (regional charcoal, firewood, crop wastes, and animal wastes breakdown), to obtain national totals. More importantly, any trends or substitutions noted in the course of the field work could be incorporated in the projection.

TABLE VI-12

HOUSEHOLD ENERGY DEMAND PROJECTION

	AVERAGE YEARLY GROWTH RATE 1980-1985	AVERAGE YEARLY GROWTH RATE 1980-1990
LPG	20%	10%
Kerosene[1]	18.5%	14.8%
Gasoil	-5.0%	-5.0%
Wood	2.5%	2.5%
Crop Residues	2.5%	2.5%
Animal Wastes	2.5%	2.5%
Vegetable Oil	2.5%	2.5%
Charcoal	4.2%	4.2%

1 A gradually decreasing growth rate was selected for kerosene, similar to GPC's Restricted Forecast (May 1982), which averages about 23.5% p.a. for 1982-1985.

Population projections to the year 2000 were prepared by M. Khide of the Dept. of Statistics. The results are presented in Table VI-13.

8. Electric Generation

The fuel requirements for the NEC have been calculated on the basis of the expansion plans in Power III and assumptions on what will be built beyond Power III up to 1990. As noted in the first section of this chapter, this approach does not consider the growth in demand of electricity as defined by the needs of local industry, local commercial establishments, agricultural and municipal pumping stations, households, etc. The historical levels of electric consumption are not an accurate measure of electricity demand, because the sales of electricity have always been constrained by the existing electric generation equipment, existing transmission lines and by the geographical location of potential load centers.

It is valuable to study the methodology by which Power III and the draft reports of Power IV calculate growth in electricity demand. The general approach is to add to the current load of each grid or single power station the new large loads to be connected (such as new industries, commercial buildings, hotels, etc.) on top of a uniform growth rate for the current load of about 7-10% per year. This approach omits the towns and regions where no electricity is currently provided. In order to incorporate these demands, Power IV follows a procedure of providing a fixed amount of electricity per capita in all population centers larger than a predetermined size. The final step is to calculate the size of the equipment by taking to account electric demand, the geographical distribution of the load and the planned interconnections.

The planned expansion can be grouped into three areas: The Blue Nile Grid, Port Sudan and all other areas. Tables VI-14 and VI-15 summarize the expansion

TABLE VI-13

PROJECTED URBAN-RURAL POPULATION BY PROVINCE

(in 000's)

Years	1973			1980			1985			1990			1995			2000		
Provinces	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Blue Nile	807	151	656	1048	301	747	1250	464	786	1485	691	794	1747	978	769	2027	1318	709
White Nile	921	153	768	1195	280	915	1426	414	832	1695	600	1095	1993	845	1148	2313	1147	1166
Gezira	1941	219	1722	2520	333	2187	3006	436	2570	3572	575	2997	4201	748	3453	4873	955	3919
Nile	563	135	428	606	182	424	646	225	421	691	276	415	740	334	406	791	400	391
Northern	376	39	337	404	51	353	431	63	368	460	76	384	493	92	401	528	111	417
N. Dar Fur	925	99	826	1140	163	977	1314	227	1087	1508	312	1196	1718	424	1294	1937	564	1373
S. Dar Fur	1202	94	1108	1480	178	1302	1706	273	1433	1959	413	1546	2232	605	1627	2516	860	1656
Kassala	1073	234	839	1496	420	1076	1731	569	1162	1992	761	1231	2279	998	1281	2583	1266	1317
Red Sea	444	160	284	586	230	356	678	282	396	780	343	437	890	414	476	1008	492	506
N. Kordofan	1181	172	1009	1343	231	1112	1487	287	1200	1663	359	1304	1882	452	1430	2156	567	1689
S. Kordofan	967	103	864	1099	188	911	1217	281	936	1361	416	945	1540	604	936	1764	856	908
Khartoum	1109	794	315	1600	2561	344	2029	1676	353	2560	2202	358	3206	2847	359	3954	3606	348
Bahrelghazal	778	79	699	870	165	705	971	270	701	1089	423	666	1223	612	611	1374	855	519
Lakes	547	41	506	612	91	521	684	156	528	766	257	509	860	396	404	967	572	395
E. Equatoria	812	148	664	909	320	589	1015	509	506	1138	740	398	1278	988	290	1436	1235	201
W. Equatoria	397	74	323	444	162	282	496	259	237	556	375	181	623	497	126	701	618	83
Upper Nile	772	54	718	863	100	763	964	153	811	1086	232	848	1213	346	767	1364	498	866
Jonglei	415	-	-	465	14*	-	519	-	-	582	-	-	653	-	-	734	-	-

Table VI-14

NEW ADDITIONS TO CAPACITY TO 1990

New 1983 - 1985	Capacity	Generation	Fuel Demand
Blue Nile Grid:			
Roseires 5, 6 hydro	80MW	420 Gwh	--
Khartoum No. 1, 2 steam	60 MW	315 Gwh	84,000 Tonnes furnace oil
Burri Rehabil, steam[1]	NA	NA	NA
Burri Extension, diesel	40 MW	175 Gwh	52,000 tonnes gasoil
Port Sudan:			
French project, diesel	15 MW	66 Gwh	19,500 tonnes gasil
NEC unit, diesel	15 MW	66 Gwh	19,500 tonnes gasoil
Other Systems:			
Total, Diesel Sets	16 MW	NA	20,800 tonnes gasoil
New 1986 - 1990			
Blue Nile Grid:			
Roseires 7, Hydro	40 MW	210 Gwh	--
Khartoum No. 3, 4 steam	60 MW	315 Gwh	84,000 tonnes furnace oil
Other Systems:			
Total, diesel sets	23 MW	NA	29,900 tonnes gas oil

[1] The Burri Rehabilitation will not add capacity to the existing system.

Table VI-15

YEARLY FUEL DEMAND, NEC SYSTEM 1982 - 1990

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Blue Nile Grid									
Hydro (Gwh)	710	710	762	1183	1183	1183	1183	1393	1393
Furnace Oil (000 tonnes)	44	44	128	128	128	128	128	212	212
Gasoil (000 tonnes)	24.2	76.2	76.2	76.2	76.2	76.2	76.2	76.2	76.2
Port Sudan									
Gasoil (000 tonnes)	8.5	27.9	47.5	47.5	47.5	47.5	47.5	47.5	47.5
Other Systems									
Gasoil (000 tonnes)	17.5	28.0	33.0	38.3	43.0	48.1	53.9	60.4	68.2

of the NEC systems incorporated to these projections. In the case of the Blue Nile Grid, the expansion indicated here is in general agreement with that in the Power III and early drafts of the Power IV documents. For the other systems, however, the growth tabulated is considerably lower than that planned by the NEC.

9. Projection Results

Tables VI-16 and VI-17 contain the resulting energy balances for 1985 and 1980 respectively.

TABLE VI-16

PROJECTION OF ENERGY CONSUMPTION 1985
('000 tonnes except where noted)

	Hydro-power (Gwh)	Benzine Avgas	LPG	Kerosene Jetfuel	Gasoil and Diesel	Furnace Oil	Wood	Charcoal	Other Biomass	Vegetable Oil
Industry				53.47	90.98	280.8	251.3		1318.	
Transport		238.7		57.45	315.96					
Agriculture					115.0					
Comm' Gov't, Services, Constr. Oil Exploration					52.09		119.2	73.9		
Households			9.85	39.26	28.0		8866	3008	1713.3	9.6
NEC Electric Generation	1183				162.0	128.0				
	1183Gwh	238.7	9.85	150.18	764.03	408.8	9236.5	3081.9	3031.3	9.6

TABLE VI-17

PROJECTION OF ENERGY CONSUMPTION 1990
('000 tonnes except where noted)

	Hydro-power (Gwh)	Benzine Avgas	LPG	Kerosene Jetfuel	Gasoil and Diesel	Furnace Oil	Wood	Charcoal	Other Biomass	Vegetable Oil
Industry				53.47	102.66	305.9	296.0		150.8	
Transport		325.4		77.2	388.84					
Agriculture					122.9					
Comm' Gov't Services, Constr. Oil Exploration					50.45		140.2	86.0		
Households			15.86	78.22	21.66		10,039	3696.	1,940.3	10.9
NEC Electric Generation	1393				191.9	212.0				
	1393Gwh	325.4	15.86	208.89	878.4	517.9	10,475.2	3782.0	2,091.1	10.9

VII. LIST OF COMMITTEES/NEA STAFF

1. ACKNOWLEDGEMENTS: NEA STAFF

Mohammed El-Amin Mukhtar, Director General
Gaafer El-Faki Osman Ali, Acting Director General

Ismail El-Gizouli, Sen. Project Counterpart
Abdallah Mohammed El Hassan
Ishag Adam Bashir
Seif El-Dawla Moh. El-Hassan
Abdel Bagi Odman Mohammed
Ahmed El-Zein El-Hassan
Hamed Ali El-Nasri
Abdel Salaam Ahmed Abdel Salaam
Nour Abdel Hamid Kheiry
Ali Abdel Karim Abdallah
Ismail Shams El-Din Shafei
Abdel Halim Ahmed El-Sheikh
Tag El-Din Hassan Moh. Ali
Mohammed Salih Farah
Gaafer Ahmed Dafalla
Einass Mohammed Abdel Rahman
Farah Abdel Magid Farah
Mohammed Fawaz Moh. Ali

NEA Special Advisors/Consultants

Hamza Homoudi
Mohammed Ali Yousif
Farouk Shaalan

Ahmed Zakaria Ahmed
Ibrahim Eissa Sobi
Ibrahim Adam Hussein
Ahmed Khalid Ahmed
El-Sadig El-Zubeir Mohammed
El-Tayeb Ibrahim Sabeel
Igbal El-Sadig Moh. Ahmed
Abu Bakr Mahgoub Mukhtar
Ahmed Osman Hamed
Bulgis Suleiman Abdel Gadir
Bakri Osman Hamed
Gamal Osman Abu Bakr
Hassan Bashir Nimr
Hamdan El-Tom Ali
Khalafallah Moh. Ahmed
Soad Sidig Ahmed
Sharif Osman Abdel Rahman
Safaa Ali Mutawali
Salah El-Din Ibrahim Awadalla
Salah Ali Moh. Nour
Salah Moh. Hassanein

Abdalla Abdel Mutaal
Abdalla Hamed El-Azrag
Ali Ahmed Osman
Abdel Moneim Mohammed Abdel Razig
Hassan Moh. Osman
Fatin Ali Moh. Adam
Fatima Ibrahim Anis
Kawther Abdel Sadig Ali Assad
Kawther Abdel Gadir El-Sheikh
Muna Ahmed Yassin
Muna Ismat Maini
Mariam Ahmed Musa
Mahmoud Rashad El-Hakim
Maha Moh. Ahmed Suleiman
Maha Ali El-Said El-Faki
Mohammadein El-Tigani Seif El-Nasr
Neimat Moh. El-Amin
Nageeb Mukhtar Mohammed
Dafalla Moh. Abdel Rahman
Abdel Moneim Abdel Gadir
Abdel Azim Moh. Ali

2. ISTI-E/DI PROJECT TEAM MEMBERS

Samuel Hale Jr.; Project Manager
Nihal Goonewardene; Deputy Project Manager
D. Michael Bess; Project Field Manager
Paul F. Cough; Deputy Project Field Manager
Constantine Salame; Renewable Resource Assessment
Andres Doernberg; Energy Supply-Demand Balances, Transport
Matthew Milukas; Industrial Energy Assessment
Shibu B. Dhar; Power Sector
Paul Thorne; Industrial Energy Assessment, Industrial Energy Efficiency and Conservation Training
Douglas MacDonald; Petroleum Allocation and Distribution
Steven Kyle; Energy Supply-Demand Balances
Asif Shaikh; Economics
Airia Roulette; Information Systems Development
Kenneth Potter; Petroleum Supplies and Allocation Training
Brian Robinson (NIFES, U.K.); Industrial ENergy Efficiency
Dr. William Prast (Atlantis, Inc.); Petroleum Allocation and Distribution Training
Prof. Peter Meier (EMTP, SUNY Stony Brook); Energy Economics
Dr. William Gross; Renewable Resources

3. U.S.A.I.D. S & T/EY SPECIAL PROJECT ASSISTANCE TEAMS

Decentralized Hydro-Power Assessment

Samuel Bunker, Jr.; Team Leader, National Rural Electrification and Cooperatives Association (NRECA)
Dr. David Zoellner; NRECA
Dr. Ralph Brooks; Tennessee Valley Authority (TVA)
Dr. Ron Domer; Tennessee Valley AUthority (TVA)

Biomass Resources Assessment

Dr. Paul Weatherly; Team Leader, S & T/EY.
Dr. Bill Ramsey; Resources for the Future
Dr. George Beinhart; U.S. Dept. of Agriculture

4. INDUSTRIAL SECTOR COMMITTEE

Sudanese Industrial Association

Eng. Mustafa Abdel Rahim(Committee Chairman)
S/ Fouad Ahmed Mekki(Mekki Enterprises)
S/ Mohammed Makawi Mustafa(Makawi)
Dr. Khalil Osman(Gulf Int'l)
Dr. Ahmed Izz El-Arab
Eng. Yousif Zaki(Sharaf Int'l)
S/ Gilbert Brahamsha(Bittar Group)
Dr. Abdel Rahman Shulli(Total-NITOC)
S/ Tah El-Roubi(El-Roubi)

Special Advisor to the Minister of Energy and Mines

Eng. El-Sir El-Khatim Moh. Salih

Ministry of Transport

S/ Omer Mahmoud

Ministry of Finance and Economic Planning

S/ Abdel Hamid Gabani

Ministry of Industry

S/ Ali Ahmed Abbas

Ministry of Commerce, Cooperation and Supply

S/ Yousif Mohammed Abdalla

Other Agencies/Organizations

Dr. Omer El-Sheikh Omer; Director General, General Petroleum Corporation
Eng. Mohammed El-Hassan; National Electricity Corporation(NEC)
Eng. El-Amin Mohammed Yassin; NEC
S/ El-Hadi Ibrahim Hassan; White Nile Petroleum Co.

National Energy Administration

S/ Mohammed El-Amin Mukhtar, Dir. General
S/ Gaafer El-Faki Osman Ali, Act. Dir. General
S/ Ismail El-Gizouli, Energy Project Coordinator
S/ Abdulla Mohammed El-Hassan
Eng. Ishag Adam Bashir
Eng. Ahmed El-Zein El-Hassan

Secretariat

Eng. Fatima Ibrahim
Eng. Safa Mutwali
Eng. Maha Moh. Ahmed
Eng. Mohammed Abbas
Eng. Mahmoud Rashad El-Hakim

5. AGRICULTURAL SECTOR COMMITTEE

Ministry of Agriculture and Irrigation

Eng. Abbas Hidayatallah(Committee Chairman); Special Advisor to the State Minister for Irrigation
Dr. Hassan Said Ahmed; Director of Dept. of Agricultural Statistics and Economics
S/ Ahmed El-Tahir Ibrahim; Irrigation
S/ Mohammed Hanafi Obeid; Director, Inventory Section, Forestry Administration
Dr. AbdallaMohammed Miezo; Veterinary Dept.
Dr. Mustafa Mohammed Suleiman; Range and Pasture Dept.

Ministry of Finance and Economic Planning

S/ Ahmed Osman; National Planning Dept.

National Research Council(NRC)

Dr. Suleiman Gabir

Other Agencies/Organizations

S/ Mohammed Adam Galabi; Agricultural Manager, Mechanized Farming Corp.(MFC)
S/ Husseain Abu Gessiesa; Sudan Gezira Board
S/ Widdaa Abdalla; Mobil Oil Co. Sudan, Ltd.
S/ El-Zein Hassan; Sugar Corporation
S/ Abdel Azim Ahmed Mahgoub; Kenana Sugar Corporation
S/ Suleiman Abdel Rahman Shughieri; APPC
Dr. Babiker Mohammed El-Hassan; Faculty of Agriculture, U. of Khartoum
S/ Hassan Mohammed Mustafa; Distribution Chief, GPC

National Energy Administration(NEA)

S/ Mohammed El-Amin Mukhtar, Director General
S/ Gaafer El-Faki Osman Ali, Acting Director General
S/ Hamza Homoudi; Special Advisor to the NEA
S/ Ismail El-Gizouli, Energy Project Coordinator
S/a Fatin Ali Moh. Adam
S/ Abdalla Abdel Mutaal
S/ Abdalla Hamed El-Azrag

6. TRANSPORT SECTOR COMMITTEE

University of Khartoum

Prof. Dafalla Badawi(Chairman); Faculty of Engineering
Dr. Adel R. Elias; Faculty of Engineering
Dr. Yassin Meheisy; Faculty of Engineering

Ministry of Transport

S/ George Zaki

TRANSPORT SECTOR COMMITTEE (Cont'd.)

Sudan Railways Corporation(SRC)

S/ Abdel Salaam Fadlalla; Deputy General Manager
S/ Moustafa Nouri
S/ El-Gayli Khalifa

River Transport Corporation(RTC)
S/ Adam Abdel Moneim; General Manager

Roads and Bridges Corporation(R&BC)
S/ El-Mahdi El-Sheikh

Truck Owners Trade Union
S/ Mohammed Abdel Rahim
S/ Mohammed A. Sagadi

Transport Workers Trade Union

S/ Saddig A. Shamoun
S/ El-Tigani M. El-Hassan(deceased)
S/ Adam A. El-Dafia
S/ Abbas Osman Idris
S/ Ahmed Eidaros El-Kamil

Other Agencies/Organizations

S/ Abdel Rahman Suleiman; White Nile Petroleum Co.
Eng. Mubarak Omer Adam; GPC
Eng. Abdel Rahman El-Tilib; PPPPC, Ministry of Energy and Mining
S/ El-Tayed Boukhari; Sudan Traffic Control
S/ Abdalla El-Gaddal; Khartoum Province Governorate
S/ Gaafer A. Mohammed; Capital Transport Co.
S/ Omar Mahgoub Ishag; " " "
S/ Hassan A. Eisa; Shell Oil Co. Sudan, Ltd.
S/ Omer El-Leithy; " " " " "
S/ Khalafalla Abdel Moneim; Sudan National Television Network

National Energy Administration

S/ Mohammed El-Amin Mukhtar, Dir. Gen.
S/ Farouk Shaalan, Special Advisor and Committee Coordinator
S/ Gaafer Ahmed Dafalla
S/ Seif El-Dawla Moh. El-Hassan

Committee Special Advisors and Participants

Col. Ali Yassin; Police Inspector General
S/ Ahmed M. Yassin; Khartoum District Chief
S/ Ali M. Abarsi; Omdurman District Chief
S/ Ahmed Dakkam; Khartoum North District Chief
Dr. Nisar Ahmed; Transport Advisor,UNDP/IBRD Planning Assistance and Training Team, Ministry of Finance and Economic Planning
S/ Ahmed Zakaria Ahmed; NEA

7. HOUSEHOLDS AND SERVICES SECTOR COMMITTEE

University of Khartoum

Dr. Yahia Hassan Hamid(Chairman, resigned); Faculty of Engineering
Dr. Amna Bashir; Geography Dept.
Dr. Abdelbagi Abdel Ghani; Geography Dept.
Dr. Omer Said; Forestry Dept., Faculty of Agriculture
Dr. Ahmed El-Bashir; Building Research Institute
Ms. Diana Baxter; Institute of Environmental Studies(IES)
Dr. Joseph Whitney; IES

Ministry of Education

S/ El-Sanusi Ibrahim

Ministry of Commerce, Cooperation and Supply

S/ Yousif Hussein
S/ Ali El-Taher Hassan

Ministry of Finance and Economic Planning

S/ Mutassim Mohammed Abubakr

Other Agencies/Organizations

Eng. Babiker Mohammed Babiker(Chairman, resigned); Energy Research Institute
S/a Amna Dirar; Sudanese National Womens Unity Council
Dr. Gassem Yousif Badri; Ahfad College
S/ Mahmoud Khidir; Statistics Dept., Ministry of Finance and Economic Planning
S/ Hamad El-Nil Abdel Gadir; GPC
Eng. Ali Nourein; GPC
S/ Atta Husein; GPC
S/ Faisal El-Badri; Shell Oil Co., Sudan Ltd.
S/ Mohammed Moustafa Sherif; Shell Oil Co., Sudan Ltd.
S/ Adlan El-Siddig; Housing Dept.
S/ Kamal Abdel Moneim; Private sector
S/ Mohammed Hanafi Obeid; Forestry Administration, Ministry of Agriculture and Irrigation
S/ Hosab El-Rasoul Ahmed; Sudan National Television Network
S/ Essam El-Din El-Fil; Industrial Research Institute
Dr. Humeida El-Hussein; NEC
S/ Farouk Hassan Ahmed; Director, Desertification Control and Rehabilitation Program(DECARP)
S/ Mustasiem El-Amin; DECARP

National Energy Administration

S/ Mohammed El-Amin Mukhtar, Director General
S/ Gaafer El-Faki Osman Ali, Acting Director General
S/ Abdel Salaam Ahmed Abdel Salaam, Committee Coordinator
S/ Ismail El-Gizouli, Energy Project Coordinator
Eng. Abdelbagi Osman Mohammed

HOUSEHOLDS AND SERVICES SECTOR COMMITTEE(cont)

National Energy Administration(cont.)

S/ El-Tayeb Ibrahim Sabeel
S/a Muna Ahmed Yassin

Secretariat

S/ Tag El-Din Hassan
S/ Gaafar Ahmed Dafalla
S/a Neimat Mohammed El-Amin
S/a Mariam Ahmed Musa
S/ Ali Ahmed Osman
S/a Igbal El-Siddig

VIII. LIST OF EXHIBITS

EXHIBIT I: FACSIMILE OF HOUSEHOLD SURVEY INSTRUMENT
(ARABIC ORIGINAL AND ENGLISH TRANSLATION)

EXHIBIT II: INVENTORY OF SUDANESE INDUSTRY

EXHIBIT III: FACSIMILE OF INDUSTRIAL ENERGY USE DATA COLLECTION FORM

IX. SUDAN ENERGY POLICY AND PLANNING PROJECT: REPORTS AND ANNEXES COMPLETED, UNDERWAY, OR SCHEDULED FOR COMPLETION

ISTI-E/DI PROJECT REPORTS, STUDIES AND SURVEYS COMPLETED

a. "Investigation of Petroleum Supply and Distribution in Sudan;" Douglas MacDonald, E/DI Europe; June-1981, (revised Sept. 1981), 150 pp.

b. "Recommendations for the Short-Range (1981-1986) Reliability Improvement Programs; PEWC;" Shibu B. Dhar, ISTI-E/DI; Aug. 1981; 152 pp.

c. "Long-Range Electricity Futures For Sudan: Two Scenarios, 1982 - 2000" Shibu B. Dhar, ISTI-E/DI; Sept. 1981, 188 pp.

d. "An Examination of the Impact of Energy Supply Problems on Sudanese Industry and a Review of Energy Use and Energy Efficiency." Paul Thorne and Matthew Milukas, E/DI Europe and ISTI-E/DI; Nov. 1981; 120 pp.

e. "A Comparison of Sudanese Export Performance with Key Petroleum Imports." Report presented to H.E. Dr. Sharif El-Tuhami. D.M. Bess and Paul Cough. Dec. 1981; ISTI-E/DI.

PROJECT-SPONSORED OR SUPPORTED STUDIES AND REPORTS COMPLETED

a. "Kerosene Policy Study." Muna Ahmed Yassin and El-Tayeb Sabeel, NEA. May 1981 (revised Dec. 1981).

b. "Traffic Reform and Energy Conservation for Vehicles in the Capital-Khartoum Area." Farouk Shaalan and the NEA (Dec. 1981).

c. "Assessment of Road Freight Movement and the Corresponding Energy Use During 1979/80;" Farouk Shaalan and the NEA (Sept. 1981).

d. "Review of the Road Freight Movement, Report of September, 1981." NEA (March 1982).

PROJECT REPORTS, STUDIES, AND SURVEYS CURRENTLY UNDERWAY

a. "Sudan National Energy Assessment (SNEA): Executive Summary" (completed).

b. "S.N.E.A.: Base Year, 1980: Energy Supply Demand Balances; Annex I" (draft completed).

c. "S.N.E.A.: Transportation Sector Energy Balances; Annex II" (completed).

d. "S.N.E.A.: Renewable Resource Assessment" (completed).

f. "S.N.E.A.: A Review of Laws, Regulations, Statutes and Provisions Pertaining to Importation and Use of Various Energy-Intensive Products (With a Legal Review of the Effects of Political Decentralization and Regionalization on the Power, Petroleum and Forestry Sectors); Appendix I." Said Eisa Said, Advocate and Muna Ahmed Yassin, LLB. (completed).

g. "S.N.E.A.: The Problem and Causes of Debris Accumulation at, and its Effects on, the Roseires Hydro-Electric Dam: An Initial Survey; Appendix II." Hassan A. Musnad, Soba Research Institute Chief Silviculturalist (completed).

h. "Complete Translation (English) of the Provisional Order for the National Electricity Corporation Act: April 1982; Appendix III (Completed).

i. "S.N.E.A.: Current Population of Sudan and Projections to the Year 2000; Appendix IV." Mahmoud Khider, Statistics Dept. (completed).

j. "S.N.E.A.: Decentralized Hydro-Power in Sudan: A Report by the U.S.A.I.D. -Funded Team, May 1982; Appendix V." (completed, under review and discussion), National Rural Electrification and Cooperatives Association (NRECA) and Tennessee Valley Authority (TVA).

k. "S.N.E.A.: Biomass Resource Assessment: A Report by the U.S.A.I.D.- Funded Team, April 1982; Appendix VI." (completed, under review and disdiscussion), Dr. Paul Weatherly (USAID, STEY), Dr. Bill Ramsey (Resources for the Future), Dr. George Beinhardt (USDA).

PROJECT REPORTS, STUDIES, AND SURVEYS SCHEDULED FOR COMPLETION

a. "S.N.E.A.: Forestry and Woodfuels Resource Assessment; Annex IV." Sept.- Oct., 1982.

b. "S.N.E.A.: Industrial Energy Base Year, 1980, Balances."

c. "S.N.E.A.: Base Year, 1980, Agricultural Energy Balances."

d. "S.N.E.A.: Base Year, 1980, Household and Services Sector Energy Balances."

e. Note: Previous Petroleum, Power Sector and Industry Assessment Reports (1. a-e, above) are formal annexes to the S.N.E.A. Report.