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SUDAN

POWER IV PROJECT BRIEF

November 11, 1983

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#### I. Sector Development Issues, Objectives and Strategy

##### Introduction

1.01. This paper is a brief on the background, details and financing requirements of the proposed Power IV Project for the members of the Consultative Group prior to their meeting in December 1983.

##### Organization of the Power Subsector

1.02. The power subsector is the responsibility of the Ministry of Energy and Mining. Prior to May 1982, power and water supply sectors were governed by the Public Electricity and Water Corporation Act of 1980 (PEWC Act). The Public Electricity and Water Corporation (PEWC) was the main producer and sole distributor of public electricity in Sudan. In May 1982, the PEWC Act was repealed and substituted by the National Electricity Corporation Act of 1982 and the Khartoum Water Corporation Act of 1982. The new Acts have introduced radical changes in the organization of the power and water supply sectors through separation and regionalization. The National Electricity Corporation (NEC) was established with responsibility for developing and managing the power facilities of the national grids (the Blue Nile Grid and the Eastern Grid) and the high voltage distribution system in the Khartoum area. Power operations outside these areas are to be transferred to regional administrations. The operation of the electricity distribution system in the Khartoum Province will be separated from NEC and taken over by a new organization in several years time.

1.03. The legal and regulatory framework for electricity organizations in the regions is virtually non-existent and therefore, NEC is providing assistance in administering the regional electricity operations until regional organizations are created by appropriate legislation and are suitably staffed. NEC has drafted legislation for enactment by the Regional Governments and is assisting them in reviewing, modifying and finalizing the preparation of legislation for each region so that electricity organizations can be established by them. The Government intended to request USAID to assist in establishing these organizations. NEC estimates that the Regional Governments will be in a position to take over the management of almost all of the isolated electricity systems from July 1984.

##### Operations and Maintenance

1.04. NEC is beset by inadequate maintenance procedures and practices. NEC has therefore obtained the services of consultants, financed by USAID and IDA, to help improve these areas, and has also embarked on a training program financed by ODA and IDA. NEC's difficulties are compounded by lack of spare parts and materials due to the virtual unavailability of foreign exchange on a regular and systematic basis. NEC depends almost entirely on

foreign loans and credits for imported materials. The proposed project therefore includes procurement of spares and materials as one of its components.

#### Financial Position of NEC

1.05 Under the terms of IDA Credit 1006-SU for Power III Project, the Corporation was required to earn a rate of return of 8% on its average net revalued fixed assets for electricity operations. This requirement was designed to help the Corporation generate funds for operations, debt service, development and working capital needs. After the tariff adjustment which went into effect from July 1, 1979, the Corporation met the rate of return of 8% for electricity operations in FY80. NEC did not increase its tariffs to reflect increases in costs subsequent to that date and consequently, it has failed to achieve the covenanted rate in FY81, FY82 and FY83. The Corporation's financial position therefore, has been extremely weak. Government has now approved an NEC proposal for tariff increases ranging from 143% for domestic consumers to 278% for small farms. NEC implemented the first stage of a two stage increase in tariffs for consumption from April 1, 1983. The increase implemented in this stage averaged about 100 percent. NEC's Board of Directors and the Ministry of Finance have approved the second stage of the increase to take effect from October 1, 1983. The incremental increase in the second stage is of similar magnitude to that in the first stage, thus bringing about a total increase of about 200 percent over the pre-April 1983 tariff levels. These increases apply to the Blue Nile and Eastern Grids, being areas under NEC management. Similar increases are being implemented in the Northern Region but not in other regions.

1.06 Presently arrears in collections of accounts receivable amount to about one year's billings. The arrears arise largely from Government institutions and Government-protected industries. NEC stated that they have an agreement with the Ministry of Finance that the Ministry will settle these accounts against presentation of certified bills. However, in practice the payments are often based on amounts budgeted for power consumption which tend to be less than billings. At the same time NEC owes the Government and its various departments and corporations substantial amounts in respect of dues such as customs duties, port charges, freight and supply of fuel oil. NEC is in the process of selecting and employing an expatriate Finance Director, and until he takes charge no progress in settling accounts with the Government can be expected because there is a virtual absence in NEC of accounts staff of the required caliber.

#### Present Power Facilities and Service

1.07 Hydroelectric power presently supplies about 87% of public supply of Sudan's electric energy requirements. The Nile River and its major tributaries represent the most important resource for hydroelectric development in the Sudan. The hydrological characteristics of the Nile and its tributaries are well defined based on detailed discharge records dating back to 1900. These characteristics give rise to two critical conditions in determining potential hydroelectric output. Firstly, water availability during the dry season (March-May) limits the amount of energy that can be generated. Secondly, the low reservoir levels during the early part of the

flood season combined with high downstream water levels resulting from large flood flows severely reduce the head available for power generation. The net result is that the maximum power output at the height of the flood season can be reduced to less than half the installed capacity. In addition, the waters of the Nile are also used for irrigation, which further limits the extent to which the hydro potential can be realized for power generation.

1.08 The present public electricity installed capacity is about 307 MW, of which 160 MW is hydroelectric and the balance is thermal. However, due to age and lack of spare parts and major overhauls, the reliable capacity is of the order of 214 MW. The principal generating and transmission facilities are located in the Blue Nile Grid (BNG) along the Blue Nile with an installed capacity of 229 MW, of which 147 MW is hydro. The BNG produces about 87 percent of the public electricity systems' total generation and supplies: (a) the city of Khartoum and surrounding areas, as well as Sennar, Damazin, Wad Medani, Hassa Heissa, Es Suki, Singa and other individual centers; and (b) irrigation schemes at Sennar, Wad El Hadad, Guneid, Rahad and Gezira. A smaller grid (Eastern Grid; EG) connects hydroelectric and diesel power stations at Khashm El Girba and New Halfa Sugar Factory. The EG is being extended to Kassala. Total installed capacity in the area is 27 MW of which 13 MW is hydro. Power plants connected to the BNG and EG will continue to be owned, operated, and maintained by NEC. The remainder of the public electricity capacity (51 MW; all diesel)<sup>1/</sup> is made up of a number of isolated stations in other areas. These stations are presently owned and operated by NEC but they will be transferred to the regional organizations (para. 1.02).

1.09 The public electricity systems supply electricity to about 276,000 customers in Sudan, of which about 210,000 are located in the BNG. The distribution of electricity consumption by categories during FY83 is given below:

	----- FY83 -----	
	NEC's Blue Nile Grid	
	GWh	%
<u>Billed Consumption</u>		
Residential	302	32
Bulk Supply (Industrial and Large Irrigation)	286	31
Small Irrigation	19	2
Commercial and other categories	71	8
	<u>677</u>	<u>73</u>
<u>Losses &amp; Unbilled Consumption</u>	<u>256</u>	<u>27</u>
Total Generation	<u>933</u>	<u>100</u>

1/ Actual sent out capacity in 1983: only 19 MW.

Electricity generation in the BNG has increased annually at an average rate of 8.7 percent from 489 GWh in FY75 (a year in which NEC was able to supply all the demand) to 933 GWh in FY83. Simultaneously, the maximum power generated on the main system increased from 86 MW in FY74 to 158 MW in FY83. Sales in the BNG were 375 GWh in FY74 and increased to 677 GWh in FY83, and losses increased from 17% of generation in FY74 to about 27% in FY83. Losses have been consistently above 20% of generation since FY87. Some of the losses are attributable to unmetered consumption.

1.10 Although some new generating capacity has been added in recent years to the BNG and isolated systems, severe supply constraints exist throughout the country. NEC has had to implement a program of planned reductions in power supplies. The BNG has also experienced considerable unplanned power cuts. Thus, in the BNG area, a growing number of consumers have installed their own generating plant to ensure power supply during the periods that NEC has been unable to meet fully the demand on its system. Total privately-owned capacity is estimated to be about 100 MW, i.e equal to one third of NEC's public electricity system installed capacity. Nevertheless, there is some demand which is not served because many potential consumers who have applied for electricity connections have yet to be connected.

1.11 The ongoing Power III project includes the installation of generating capacity totalling about 180 MW (60 MW fuel oil fired power plant at Khartoum North, 80 MW hydro units at Roseires, and 40 MW diesel sets at Burri). Completion is scheduled for October 1984 shortly after which time the forecast system peak demand is close to the system's firm generation capacity. Thus, installation of additional generation capacity would be needed immediately after the completion of the ongoing project. NEC requested the Bank to help in financing the preparation of the next project. Upon Bank's agreement, NEC signed on March 7, 1982 a contract with its consultants for the preparation of a feasibility study for the Power IV Project. The final report was issued in June 1983.

#### Power Development Strategy

1.12 Power demand forecasts for the BNG, Eastern grid, Port Sudan and individual regions have been reviewed and updated by the consultants to NEC, under the terms of reference for the Power IV Feasibility Study. An IDA appraisal mission reviewed, with NEC and the consultants, the present situation regarding billings, unbilled consumption, load shedding and demand for power. The mission believes that the underlying growth rate in demand for power to 1990/91 is about 7.3%/year. Under this forecast additional generation capacity will be required by end 1987.

1.13 The ultimate hydroelectric potential of Sudan exceeds 2,000 MW, compared with an actual installed capacity of all hydroelectric plants of 160 MW in the public systems. However, there are major constraints on development of hydroelectric resources in the Sudan due to the high investment cost associated with the large reservoirs required to realize the hydroelectric potential of the River Nile since the river has a gentle gradient, as well as to limitations on firm power capacity (para. 1.07). Furthermore, preparation and construction of any of the hydro-electric options would require more time than is available before additional generation capacity

will be needed following the Power III project. Therefore, such additional capacity will have to be based on thermal generation. The Power IV project thus includes additional thermal generation capacity.

1.14 There are major issues concerning investment strategy in the power sector for the period beyond FY89 that need to be resolved. Due to the long lead times required to realise investments, some of these issues should be examined soon. Major issues include the role of domestic oil and gas in power generation and the most economic means of developing Sudan's hydroelectric potential given the difficulties associated with such development. The optimal timings of development of water resources for power generation and irrigation are not always coincident and thus, decisions on hydroelectric development have to take account of irrigation development priorities. An analysis of multi-purpose water development was undertaken in the Nile Waters Study in 1980. However, much of the information in the report, especially concerning costs and prices, needs to be updated. The proposed program for irrigation development given in the report is being revised by USBR. Since the program included projects, such as the Upper Atbara dam and heightening of Roseires dam, which would allow hydroelectric development, proposals for irrigation developments should be taken into account in long range power planning. Because of the long lead time required for the realization of large hydroelectric schemes, Sudan has to start detailed feasibility studies for the next major scheme soon if it is to have the option of commissioning the scheme by the mid 1990's. A pre-feasibility study for the Merowe hydroelectric project is being financed by the Government of Sweden. The development of the Merowe project will not be substantially affected by irrigation planning.

1.15 In view of Sudan's current financial crisis and the need for the earliest possible recovery of export performance, the Government's strategy is to finance investments in: (a) completion of ongoing high priority projects; (b) rehabilitation of earlier projects, particularly in the irrigation subsector; and (c) infrastructure facilities necessary to support (a) and (b). The current public investment program allocates about 14 percent of total public investment to the power sector. Presently power shortages constitute a major constraint on the nation's economic recovery. Consequently priority needs to be given to the rehabilitation and development of electricity generation, transmission and distribution facilities in those regions of the country which contribute to the overall economic development. Most of these regions are in the areas served by the BNG and Eastern Grid. Therefore, the strategy for the Power IV Project should be to give priority to the facilities under the Power IV program to be built in the BNG and Eastern Grid.

## II. The Proposed Power IV Project

2.01 The proposed Power IV Project is a group of components drawn from NEC's Power IV Program. The selected components are considered by NEC and the Bank to have highest priority in accordance with the overall strategy for the economy (para. 1.15). The remaining components were omitted because the total cost of the Power IV program was considered to be substantially in excess of the financial resources that are likely to be available for power development in the Sudan during the next few years.

## Objectives

- 2.02 The main objectives of the proposed Power IV project are:
- (a) to rehabilitate existing facilities in the Blue Nile Grid (BNG) and the Eastern Grid (EG), and to assure their efficient operation through the provision of spare parts, in conformity with the Government's strategy for the economy;
  - (b) to provide additional generation capacity in the BNG and EG to meet at least cost the forecast increase in demand during the latter part of the 1980s;
  - (c) to increase transmission capacity in both grids to transmit the generated energy to the main load centers;
  - (d) to increase the capacity of the subtransmission and distribution networks in the Khartoum area and areas of the BNG outside Khartoum to improve reliability of supply;
  - (e) to continue efforts for institutional improvements and strengthening of NEC's organization and operation through comprehensive management and staff training programs which are being carried out through Power III Project;
  - (f) to carry out a load management and energy conservation study; and
  - (g) to provide fuel oil transportation equipment to assure supply of fuel oil requirements to thermal power stations in the Khartoum area.

## Project Description

- 2.03 The description of the proposed Power IV project is as follows:
- A. Expansion of Facilities on the Blue Nile Grid<sup>2/</sup>
- (a) addition of the 7th unit (turbine and generator) at Roseires hydroelectric station (40 MW);
  - (b) construction of the 3rd and 4th units (60 MW each) at Khartoum North fuel oil-fired power station;
  - (c) construction of the high priority transmission projects required for the development of BNG:
    - installation of the second 220/110 kV, 100 MVA transformer together with the 220 kV and 110 kV feeder bays at Kilo X substation near Khartoum;
    - installation of compensation equipment on the 220 kV Sennar Junction-Meringan-Kilo X transmission line;

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<sup>2/</sup> The Italian Government has agreed to finance the installation of 2 x 15 MW gas turbines at Kilo X power station under the Power IV Program.

- construction of the 98 km, 110 kV Sennar Junction-Rabak transmission line;
  - construction of the 100 km, 110 kV Rabak-Mashkur transmission line and of the 110/33 kV, 12.5 MVA substation at Mashkur;
  - construction of the 10 km, 110 kV Sennar-Sennar Junction transmission line (2nd circuit);
  - installation of additional 110/33/11 kV transformers to meet the growth in demand in the BNG; and
  - construction of the load dispatch center.
- (d) development of the Khartoum 110 kV and 33 kV subtransmission and 11 kV and 420 V distribution network;
- construction of 38 km of 110 kV line from Kilo X to Forest and Omdurman;
  - construction of 110/33/11kV, 17.5/10/10 MVA substations at Forest and Omdurman;
  - strengthening and extension of the 33 kV network;
  - supply of distribution transformers, switchgear and other material for an additional capacity of 115 MVA, up to 1987/88.
- (e) development of the 33 kV, 11 kV and 420 V distribution networks in the BNG outside Khartoum area:
- strengthening and extension of the 33 kV networks;
  - supply of distribution transformers, switchgear and other material for an additional capacity of 100 MVA up to 1987/88.

B. Expansion of Facilities on the Eastern Grid

- (f) development of generation (2x5 MW diesel power units at Khashm el Girba) and transmission capacity in EG;

C. Rehabilitation and Spares

- (g) rehabilitation of the BNG and EG transmission facilities;
- (h) rehabilitation of the Khashm el Girba combined hydroelectric and diesel power station (second stage);
- (i) spare parts for the generation and transmission installations connected to BNG and EG;



D. Improvement of Power Supply Reliability on BNG

- (j) transmission works required for the reliable operation of BNG:
- construction of the 3rd circuit of the 220 kV Roseires-Sennar Junction transmission line (228 km of line on single circuit towers) together with 220 kV feeder bays;
  - installation of the third 220/110 kV, 55 MVA and 40 MVA transformers at Sennar Junction and Meringan, respectively;
  - installation of 110/33 kV transformers at various substations in the BNG including the Khartoum area.

E. Increase in Fuel Oil Transportation Capacity

- (k) urgent rehabilitation of the existing stock;
- (l) procurement of fuel oil transportation equipment, including spare parts for the first two years' operation:
- 10 mainline locomotives (2 each for 3 block trains plus 2 spare);
  - 124 rail rail tanker wagons of carrying capacity of 30 tons each;
  - 4 sets of breaking vans;
  - radio communication equipment;
- (m) railway track extensions at Khartoum and Port Sudan;
- (n) additional discharge and heating facilities in Khartoum North and Burri power stations (to be built by NEC);
- (o) Engineering and technical assistance.

F. Technical Assistance and Studies

- (p) technical assistance for NEC manpower development and training;
- (q) studies for future development projects and plans:
  - update of the Long Term Power Plan of 1979;
  - feasibility study and project report for the next power project; and
  - feasibility study of the extension of the Sennar Hydro Power Plant; and
- (r) load management and energy conservation study.

Project Implementation

2.04 NEC will be responsible for the implementation of the project and will be assisted by engineering consultants. NEC is effectively supervising construction of the ongoing Power III project and much of the same staff will be available for supervision of the Power IV project.

Project Cost

2.05 The estimated project cost, excluding interest during construction, is LS 881.0 (US\$457.6 million) of which about 76 percent or LS 671.3 (US\$349.0 million) is in foreign currency. The total financial requirement, including interest during construction and the commitment fee on the IDA Credit, is estimated to be LS 1,167.5 (US\$597.5 million), of which LS 673.0 (US\$350.0) million is in foreign exchange. The cost estimates are summarized in Table 1.

Critical Path for Project Preparation

2.06 Target dates for the critical steps in the Power IV Project program are given below:

Project Financing

Discussions with Co-financiers	December 1983
Negotiations	March 1984
IDA Board Presentation	May 1984
IDA Credit Effectiveness	August 1984

Bidding (tentative)

General Procurement Notice	March 1984
Prequalification for Civil Works	May 1984
Issue of Bid Documents	June 1984
Bid Closing	September 1984
Award of Main Contracts	February 1985

Construction

Start	April 1985
Commissioning (of the two 60 MW generating units)	December 1987/April 1988

Summary of Project Cost Estimates

Table 1

<u>Project Components</u>	<u>Local</u>	<u>Foreign</u>	<u>Total</u>	<u>Local</u>	<u>Foreign</u>	<u>Total</u>
	<u>LS million</u>			<u>US\$ million</u>		
<u>A. Expansion of Facilities on the Blue Nile Grid</u>						
- Roseires Unit No. 7 (Electro-Mechanical)	1.3	16.3	17.6	0.7	8.9	9.6
- Khartoum North PS Units Nos. 3 and 4 (2 x 60 MW)	25.8	191.2	217.0	13.6	99.5	113.1
- Transmission, subtransmission and distribution projects	62.2	155.0	217.2	32.0	79.7	111.7
<u>B. Expansion of Facilities on the Eastern Grid</u>	6.6	29.3	35.9	3.6	15.9	19.5
<u>C. Rehabilitation and Spares</u>	8.4	31.9	40.3	4.5	17.1	21.6
<u>D. Improvement of the Power Supply on BNG</u>	10.8	44.5	55.3	5.6	23.0	28.6
<u>E. Increase in Fuel Oil Transportation Capacity</u>	1.1	48.5	49.6	0.6	25.5	26.1
<u>F. Technical Assistance and Studies</u>	1.2	4.0	5.2	0.8	2.3	3.1
<b>TOTAL POWER IV PROJECT</b>						
Total Base Cost	117.4	520.7	638.1	61.4	271.9	333.3
Total Contingencies - Physical	13.2	69.2	82.4	6.9	36.2	43.1
- Price	52.1	81.4	133.5	26.2	40.9	67.1
- Total	65.3	150.6	215.9	33.1	77.1	110.2
Subtotal	182.7	671.3	854.0	94.5	349.0	443.5
Custom Duties for railways, transportation equipment	27.0	-	27.0	14.1	-	14.1
<b>TOTAL PROJECT COST</b>	<b>209.7</b>	<b>671.3</b>	<b>881.0</b>	<b>108.6</b>	<b>349.0</b>	<b>457.6</b>
Interest During Construction <sup>a/</sup>	284.8	-	284.8	138.9	-	138.9
Commitment Fee for IDA Credit	-	1.7	1.7	-	1.0	1.0
Total IDC and Commitment Fee	284.8	1.7	286.5	138.9	1.0	139.9
<b>TOTAL FINANCING REQUIREMENTS</b>	<b>494.5</b>	<b>673.0</b>	<b>1,167.5</b>	<b>247.5</b>	<b>350.0</b>	<b>597.5</b>

<sup>a/</sup> All foreign currency requirements assumed to be obtained through grants or soft loans and to be onlent to NEC at an interest rate of 19%. Local currency requirements assumed to be provided by NEC.