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EASTERN NILE POWER TRADE PROGRAM STUDY

AfDB



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MARKET AND POWER TRADE ASSESSMENT

VOL 1 EXECUTIVE SUMMARY

FINAL MAIN REPORT

with participation of:

- EPS (Egypt)
- Tropics (Ethiopia)
- YAM (Sudan)

30 April 2007



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PHYSICAL UNITS AND CONVERSION FACTORS

bbbl	barrel (1t = 7.3 bbl)
cal	calorie (1 cal = 4.1868 J)
Gcal	Giga calorie
GWh	Gigawatt-hour
h	hour
km	kilometer
km ²	square kilometer
kW	kilo Watt
kWh	kilo Watt hour (1 kWh = 3.6 MJ)
MBtu	Million British Thermal Units (= 1 055 MJ = 252 kCal) One cubic foot of natural gas produces approximately 1,000 BTU
MJ	Million Joule (= 0,948.10 ⁻³ Mbtu = 238.8 kCal)
MW	Mega Watt
m	meter
m ³ /d	cubic meter per day
mm	millimeter
mm ³	million cubic meter
Nm ³	Normal cubic meter, i.e. measured under normal conditions, i.e. 0°C and 1013 mbar (1 Nm ³ = 1.057 m ³ measured under standard conditions, i.e. 15°C and 1013 mbar)
t	ton
Toe	tons of oil equivalent
Tcf	ton cubic feet
°C	Degrees Celsius

General Conversion Factors for Energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	2.388 x 10 ⁻⁵	947.8	0.2778
Gcal	4.1868 x 10 ⁻³	1	10 ⁻⁷	3.968	1.163 x 10 ⁻³
Mtoe	4.1868 x 10 ⁴	10 ⁷	1	3.968 x 10 ⁷	11630
MBtu	1.0551 x 10 ⁻³	0.252	2.52 x 10 ⁻⁸	1	2.931 x 10 ⁻⁴
GWh	3.6	860	8.6 x 10 ⁻⁵	3412	1

ABBREVIATIONS AND ACRONYMS

ADB	African Development Bank
ADF	African Development Fund
CC	Combined Cycle
CCGT	Combined Cycle Gas Turbine
CIDA	Canadian International Development Agency
CT	Combustion Turbine
DANIDA	Danish Development Assistance
DFID	Department for International Development (UK)
DIDC	Department for International Development Cooperation (GoF)
DSA	Daily Subsistence Allowance
EEHC	Egyptian Electricity Holding Company
EEPCO	Ethiopian Electric Power Corporation
EHV	Extra High Voltage
EHVAC	Extra High Voltage Alternating Current
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EN	Eastern Nile
ENCOM	Eastern Nile Council of Ministers
ENSAP	Eastern Nile Subsidiary Action Program
ENSAPT	Eastern Nile Subsidiary Action Program Team
ENTRO	Eastern Nile Technical Regional Office
ENTRO PCU	Eastern Nile Technical Regional Office Power Coordination Unit
FIRR	Financial Internal Rate of Return
GEP	Generation Expansion Plan
GTZ	German Technical Co-operation
HPP	Hydro Power Plant
HFO	Heavy fuel oil
HV	High Voltage
HVDC	High Voltage Direct Current
ICCON	International Consortium for Cooperation on the Nile
ICS	Interconnected System
IDEN	Integrated Development of the Eastern Nile
IDO	Industrial Diesel Oil
IMF	International Monetary Fund
JICA	Japanese International Co-operation Agency
JMP	Joint Multipurpose Project
LNG	Liquefied Natural Gas
LOLP	Loss of Load Probability

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LPG	Liquefied Petroleum Gas
LRFO	Light Residuel Fuel Oil
MENA	Middle East, North Africa Countries
MIWR	Ministry of Irrigation & Water Resources (Sudan)
MWR	Ministry of Water Resources (Ethiopia)
MWRI	Ministry of Water Resources and Irrigation (Egypt)
MSD	Medium Speed Diesel (TPP)
NBI	Nile Basin Initiative
NEC	National Electricity Corporation (Sudan)
NECC	National Electricity Control Centre (Egypt)
NELCOM	Nile Equatorial Lake Council of Ministers
NELSAP	Nile Equatorial Lake Subsidiary Action Program
NG	Natural Gas
NGO	Non Governmental Organization
NORAD	Norwegian Aid Development
NPV	Net Present Value
O&M	Operations and Maintenance
OCGT	Open Cycle Gas Turbine
OPEC	Organization of the Petroleum Exporting Countries
PBP	Pay Back Period
PHRD	Policy & Human Resource Development Fund
PIU	Project Implementation Unit
PRSP	Poverty Reduction Strategy Paper
RCC	Regional Electricity Control Centre (Egypt)
RE	Rural Electrification
SAPP	Southern Africa Power Pool
SIDA	Swedish International Development Agency
SSD	Slow speed diesel (TPP)
STPP	Steam Turbine Power Plant
STS	Senior Technical Specialist
TAF	Technical Assistant Fund
TPP	Thermal Power Plant
UA	Unit of Account
UNDP	United Nations Development Program
WB	World Bank

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1. EXECUTIVE SUMMARY

1.1 EGYPT

Egypt occupies the north-eastern corner of the continent of Africa, including the Sinai Peninsula, with a population of about 69.997 millions (2005), 43% in urban areas and 57% in rural areas. The growth rate of population is currently 1.96% (2006).

The economy of the country has developed in the last years with an annual GDP rate of 5%, pushed up by a significant production of petroleum products, electricity developments, and industrialization.

Egypt has a per capita electric energy consumption of 1 350 kWh (2001/2002). Access to electricity is high, around 98%, with negligible isolated systems.

Environmental improvements can be notice by the rate of CO₂ production in Egypt. It has been reduced from about 2.8 tons of CO₂ per Toe in 1981/1982 to about 2.5 in the year 2001/2002. This is because of the increase of the use of natural gas in the electric energy production.

1.1.1 EGYPTIAN UTILITY

Egyptian electric company is currently comprised of nine regional electricity distribution companies, five regional electricity generation companies, one electricity transmission companies. All these companies are blended in a Holding company, the Egyptian Electricity Holding Company (EEHC). Different authorities, such as New & Renewable Energy and Hydro Power, are directly linked to the Ministry of Electricity & Energy.

1.1.2 CURRENT DEMAND AND GENERATION SUPPLY

In Egypt, peak demand increased from 5 400 MW (1985/1986) to 17 300 MW (2005/2006). In the same period, energy generated increased from 32 TWh to 108 TWh, with a growth rate of 7% in the last ten years.

The total installed capacity in 2006 is 20 508 MW, with 17 543 MW of thermal plants, 225 MW of wind farms, and 2 740 MW of hydropower (4 plants).

Installed Capacity (MW)	ST	CCGT	OCGT	WIND	HYDRO	Total
Cairo	2270	1485	600			4355
West Delta	3330	1224	837			5391
East Delta	3991	1409	453	225		6078
Upper Egypt	1944					1944
Hydro					2740	2740
Total	11535	4118	1890	225	2740	20508
Installed Capacity (%)	56%	20%	9%	1%	13%	

Table 1.1-1 - Total installed capacity in Egypt in 2006

One hydro, two thermal plants, and two wind farms are committed:

- ✓ The New Naga-Hammadi 64 MW and 460 GWh/year is planned to operate in 2008/2009
- ✓ Talkha 750 MW CC (NG/HFO) in East Delta is planned to operate in 2007/2008
- ✓ Kurimat (2) 750 MW CC (NG/HFO) in Upper Egypt is planned to operate in 2007/2008
- ✓ Zafarana / Gabal El-Zait 55 MW is planned to operate in 2006/2007
- ✓ Zafarana / Gabal El-Zait 150 MW is planned to operate in 2007/2008

In the Egyptian hydro system, irrigation is the priority, the power production is only a by-product. The Water Resources and Irrigation Ministry defines the daily discharges in power plants and send this information to NECC every week.

1.1.3 EXISTING TRANSMISSION SYSTEM AND POWER TRADE

Egypt is interconnected with Libya and Jordan. These interconnections are used for emergency situations and for power trade between Egypt and Jordan. Exports and imports measured from 2003 to 2005 represented less than 1% of total Egyptian electrical generation, but 20% of Jordanian generation. An export balance of 20 GWh to Lybia and of 680 GWh to Jordan were measured in 2004/2005.

The existing transmission system is equipped with a double circuit 500 kV backbone along the Nile river, from High Dam (2 100 MW) to Cairo (main load centre), and a single circuit (500 KV) from Cairo to the interconnection with Jordan. A 132 kV and 220 kV circuit follows the 500 kV backbone along the Nile river. The delta zone is supplied with a meshed 220 kV network, and extends towards west to Libya with a double circuit interconnection. An extension of the 500 kV network is currently under construction from Cairo 500 to Sidi Krir in West Delta. It is also the first milestone to reinforcement of the interconnection with Libya in 500/400 kV.

1.2 ETHIOPIA

Ethiopia located in the Eastern Africa, has a population of about 75 million inhabitants. 16% of the people are urban. The growth rate of population is currently 2.8%.

The economy of the country, one of the poorest in the world, is not in line with its endowed natural resources. These resources include natural gas, coal, geothermal, considerable hydroelectric power potential, very large livestock population and extensive irrigation potential.

Ethiopia has one of the lowest levels of energy consumption per capita in the world at 28 kWh. Access to electricity is considered to be 17% of population at present.

1.2.1 ETHIOPIAN UTILITY

Ethiopian Electric Power Corporation (EPPCO) is responsible for generation, transmission and distribution of the interconnected system (ISC) as well as some isolated or self contained system (SCS). The current trend for development of generation using IPP (Independent Power Producers) which entitles EPPCO to buy generated power at negotiated rates is also encouraged.

1.2.2 CURRENT GENERATION SUPPLY

The Interconnected System (ICS) has a total installed capacity of 766,9 MW (end of 2006) including 96,3 MW of Diesel plants at Dire Dawa, Awash, and Kaliti, and a Geothermal plant at Aluto-Langano.

The existing thermal plants in the ICS (end of 2006) are as follows:

Power Plants	Plant Type	Installed capacity (MW)
Dire Dawa Diesel	Diesel	38
Awash 7 Kilo Diesel	Diesel	27
Kaliti Diesel	Diesel	12
Others	Diesel	12
Aluto Geothermal*	Geothermal	7,3
Total Thermal Power Plant (ICS)		96,3 MW
Gigel Gibe I (in 2004)	Hydro	192 (with 3 units)
Maleka Wakana (in 1988)	Hydro	153
Finchaa (1973-2003)	Hydro	134 (with 4 units)
Tis Abay I (in 1964)	Hydro	11,4
Tis Abay II (in 2001)	Hydro	73
Koka (in 1960)	Hydro	43,2
Awash II (in 1966)	Hydro	32
Awash III (in 1971)	Hydro	32
Total Hydro Power Plant (ICS)		670,6 MW

Table 1.2-1 - Existing Ethiopian power plants

1.2.3 COMMITTED POWER PROJECTS

Five hydropower projects are committed by EEPSCO in 2006 and under construction: Gilgel Gibe II and Gibe III, Tekeze, Upper Beles and Neshe which main characteristic and commissioning dates are shown in the following table:

Hydro Power Plant (Commissioning date)	Installed capacity (MW)	Average energy capacity (GWh)
Gigel Gibe II - 2008	420	1 600
Gibe III - 2012	1870	6 240
Tekeze - 2008	300	960
Beles - 2009 (w/o Tis Abay I & II)	460 (376)	2 000 (1 630)
Neshe HPP - 2010	97	225
Total new capacity (w/o Tis Abay I & II)	3 147 MW (3 063 MW)	11 025 GWh (10 655 GWh)

Table 1.2-2 - Ethiopian Committed Hydropower Projects

1.2.4 EXISTING TRANSMISSION SYSTEM AND POWER TRADE

The Ethiopian system consists mainly of 230 and 132 kV lines. The 230 kV network extends from Addis Ababa about 400 km eastward to Dire Dawa, about 300 km southward to Shashemene and about 1000 km northward to Tekeze and Gonder.

Three 230 kV substations supply Addis Ababa, that represents 60% of the total demand.

A 400 kV network will be soon erected to evacuate the generation of Gilgel Gibe II HPP until Addis Ababa.

Ethiopia will be interconnected with Sudan with a 230 kV double circuit line between Gonder and Gedaref in Sudan. The commissioning is expected in year 2008.

1.3 SUDAN

Sudan is an afro-Arab country occupying a remarkable strategic position in the centre of the Africa continent, has a population of 35 millions inhabitants. The growth rate of population is 2,6%. It shares its extensive borders with nine countries of northern, eastern, central and western Africa. Such juxtaposition engenders a mix of trade, culture, social, ethnic and other human ties built throughout history.

Agriculture remains the backbone of Sudanese economy and oil exportation is very recent.

The electrification ratio of the Sudan (percentage of households with electricity supply) is one of the lowest in the world, estimated at about 19% (made up from about 16.3% metered NEC connections, 2.3% connections to private supply companies and 0.2% unmetered connections).

1.3.1 SUDANESE UTILITY

The National Electricity Corporation (NEC) is the governmental entity responsible for generation, transmission and distribution of electric power in the Sudan. NEC's power system comprises mainly the national grid (NG) and a number of isolated diesel power stations.

The electricity system within Sudan is comprised of the main National Grid, a number of isolated off-grid systems and some existing private generation companies. NEC's main grid system is divided into the Khartoum, Central, Eastern and Northern areas.

The towns of Atbara and Shendi in River Nile state, which were previously supplied by local off-grid generation, were connected to the National Grid as part of the Merowe transmission reinforcement scheme in the second half of 2005.

1.3.2 CURRENT GENERATION SUPPLY

In 2003 Gerri I and Gerri II combined cycle power generating facilities were commissioned. Adding to the grid about 386 MW generating capacity the supply exceeds the demand and the power cuts are mainly limited to failures in transmission and distribution.

At the time being the total capacity available for dispatch on the National Grid is about 826 MW, of which some 59% is conventional thermal plant and the remaining 41% is hydroelectric plant.

In the table here below, is set out the generation mix on the National Grid as at July 2006 and provide a summary of installed and available capacities from the existing on-grid power plants.

Power Plant	Plant Type	Fuel Type	Net Capacity (MW)
Khartoum North ST's	Thermal	HFO	157.0
Khartoum North GT's	Thermal	Gas Oil	50.4
Garri 1 CCGT's	Thermal	Gas Oil	164.0
Garri 2 OCGT's	Thermal	Gas Oil	84.0
El Fau Diesel	Thermal	Gas Oil	10.0
Kassala Diesel's	Thermal	Gas Oil	7.9
Girba Diesel's	Thermal	Diesel	4.0
Kuku GT's	Thermal	Gas Oil	19.0
Total Thermal Plant			496.3
Roseires	Hydro		280.0
Sennar	Hydro		15.0
Kashm El Girba	Hydro		18.1
Jebel Aulia	Hydro		28.1
Total Hydro Plant			341.2
Net Installed Capacity			837.5
Thermal Capacity Part			59%
Hydro Capacity Part			41%

Table 1.3-1 - Existing Sudanese power plants

1.3.3 COMMITTED POWER PROJECTS

According to NEC master plan, the following power plants have been identified as committed contributors to the Sudan generation expansion plan.

- Khartoum North Units 5 and 6 (100 MW each – 2008)
- Conversion of Garri 2 power station to combined cycle operation (200 MW – 2008)
- Kilo X GT (80 MW - 2007)
- Garri (3) steam plant (540 MW - 2010)
- Garri (4) steam plant (100MW – 2007)
- Port Sudan steam plant (405 MW – 2009)
- Kosti steam plant (500 MW – 2010)
- El Bagair steam plant (540 MW – 2010)

- Kassala diesel plant (50 MW – 2007)
- Al Fula steam plant (540 MW – 2010)
- Merowe hydroelectric plant (1 250 MW – 2008)
- Sennar extension hydroelectric plant (1 250 MW – 2008)
- The heightening of the Rosieres hydroelectric plant, with Dinder (135 MW – 2012)

1.3.4 EXISTING TRANSMISSION SYSTEM AND POWER TRADE

At present there is no international power trade between Sudan and the neighbouring countries. This is partly because until today there was no transmission facilities to enable such trade.

The Sudanese system consists mainly of 110 and 220 kV lines. The system includes a 800 km 220 kV double circuit line from Roseires HPP, located in the south close to Ethiopia border, to Khartoum along to the Blue Nile River. A 110 kV double circuit ring supplies Khartoum, that represents 50% of the total load. This 110 kV ring is connected to the 220 kV system with two 220/110 kV substations at Eid Babiker and Kilo X.

In the coming year 2007, the network will be reinforced with a 500 kV double circuit line from Merowe HPP (installed capacity 1 250 MW) to Khartoum and a 500 kV single circuit line between Merowe and Atbara located on the Nile, 300 km north east of Khartoum.

In the next years, NEC intends to extend its 220 kV system by about 2 000 km of new lines.

2. ORGANISATION OF MODULE 2 REPORT

Module 2 deals with the assessment of the existing market and power trade situation in the Egypt, Ethiopia and Sudan.

This Module is organized in four Volumes:

- Volume 1: Overview of Module M2.
- Volume 2: Market of Power Trade assessment for Egypt.
- Volume 3: Market of Power Trade assessment for Ethiopia.
- Volume 4: Market of Power Trade assessment for Sudan.

Each volume from Vol 2 to Vol 4 analyses the existing situation in each country along the following items:

- Review of the electricity sector.
- Assessment of existing generation mix (TPP, HPP, geothermal, etc).
- Assessment of existing power trade.
- Assessment of existing transmission system.