Notice of Violation of IEEE Publication Principles

"Status of International Interconnections and Electricity Deregulation in Africa,"
by T.J. Hammons,
in the Proceedings of the 39th International Universities Power Engineering Conference 2004 (UPEC), vol.1, pp. 26-33, 6-8 Sept. 2004

After careful and considered review of the content and authorship of this paper by a duly constituted expert committee, this paper has been found to be in violation of IEEE's Publication Principles.

This paper is a near duplication of the original text from the papers cited below. The original text was copied without attribution and without permission.

Due to the nature of this violation, reasonable effort should be made to remove all past references to this paper, and future references should be made to the following articles:

"Impact of Privatization and Deregulation on Infrastructure Development in Africa,"
by R. Johnson,
in the Proceedings of the 2004 IEEE Power Engineering Society General Meeting, June 2004

“Status of International Interconnections and Electricity Deregulation in Africa—An Overview of the Current Status in Southern Africa,”
by Jan A. de Kock,
in the Proceedings of the 2004 IEEE Power Engineering Society General Meeting, June 2004

“Status of International Interconnections in North Africa”
by Ahmed Zobaa,
in the Proceedings of the 2004 IEEE Power Engineering Society General Meeting, June 2004

“Towards Developing a Competitive Market for Regional Electricity Cross Border Trading: The Case of the Southern African Power Pool,”
by P. Naidoo, L. Musaba, W. Balet, A. Chikova,
in the Proceedings of the 2004 IEEE Power Engineering Society General Meeting, June 2004

“Status of Gulf Co-operation Council (GCC) Electricity Grid System Interconnection”
by A Majeed, H.A. Karim, N.H. Al Maskati, S. Sud,
in the Proceedings of the 2004 IEEE Power Engineering Society General Meeting, June 2004

STATUS OF INTERNATIONAL INTERCONNECTIONS AND ELECTRICITY DEREGULATION IN AFRICA

T. J. Hammons, Chair International Practices for Energy Development and Power Generation
University of Glasgow, United Kingdom
T.Hammons@ieee.org

Abstract: The paper reviews the present status and future prospect of international interconnections, infrastructure, electricity exchanges, and deregulation in Africa from the viewpoint of generation and transmission development, global deregulation trends and policies, development of a competitive market for regional electricity cross-border trading, and status of the Gulf Co-operation Council (GCC) Electricity Grid System interconnection. In particular, the case of the Southern Africa Power Pool in developing a competitive market for regional electricity cross border trading; GCC Electricity Grid System interconnections; and economic benefits and strategic new international transmission in the Southern African Power Pool (SAPP), are some of the topics that are presented and discussed in this paper.
KEYWORDS: African power grid, Southern African Power Pool, Gulf cooperation council, North African electricity interconnections, electricity deregulation, stability, cross border trading, pricing of electrical energy, competitive markets, electric power generation in Africa, privatisation, generation expansion, transmission expansion, Africa, public/private partnerships, energy markets.

1. INTRODUCTION

This paper considers the present status and future prospect of electricity infrastructure in Africa not presented in the literature in a convenient form heretofore. It examines generation and transmission development, global deregulation trends and policies, the development of a competitive market for regional electricity cross-border trading, and status of the Gulf Co-operation Council (GCC) Electricity Grid System interconnection.

Interconnection of electric power systems of regions, states and individual territories is acquiring a growing scale of importance in world practice. Examples of this influence and studies to date are presented. Key to this is focus on the projected development of power pools in various regions and their interconnections domestically and internationally. There are many benefits of this tendency because of the so-called system effects that lead to improving economical, ecological and technological efficiencies of the joint operation of electric power systems. The effort to limit GHG emission is one such major benefit. Another important benefit with institutional wide implications is the modeling of these initiatives.

Africa, and the Middle East are very favorable regions for electric power grid creation and using the above system effects on account of different levels of economic development in different countries of the region, different placement of fuel and energy resources, and consumers, etc. Therefore, the analyses of the present status and prospective trends of Africa and Middle Eastern Electricity interconnections and efforts to improve efficiency and limit GHG emission and bridging the digital divide are very important problems.

Regional electricity cross border trading is governed by fixed co-operative bilateral agreements; generally of a long-term duration. The fixed power purchase agreements provide for the assurance of security of supply but are not flexible to accommodate varying demand profiles and varying prices. The pricing of electrical energy defers for periods of peak and off peak consumption. Research has shown that competitive bidding is one option for sourcing and securing supplies closer to real time dispatch.

2. OVERVIEW OF THE CURRENT STATUS IN SOUTHERN AFRICA

Africa is a vast continent. In Africa south of the equator only South Africa has a well-developed and meshed grid with large generating capacity to support industry and development. Most of the southern African counties are in one way or another dependant on South Africa for supplying the balance of the power consumed and in stabilising their grid network. This is achieved by co-operation within the Southern African Power Pool (SAPP). The SAPP consists of the state-owned utilities of Botswana, Democratic Republic of the Congo (DRC), Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zimbabwe, and Zambia that are all interconnected. The total maximum demand of SAPP was 35.9 GW in 2001/2 of which South Africa consumed 30.6 GW. The total installed capacity is 48.3 GW with the South African contribution 41.3 GW . Typically South Africa's neighbours produce most of their own power. South Africa produced 87.6 % of the consumed energy in 2001/2 [1].

2.1 Power System Stability

The SAPP main grid is stable and the frequency control is good [2]. This applies to the main grid connections. However, the level of interconnectivity in counties outside South Africa is low. This means that faults and power swings can have a severe effect on the stability of the grid.

The generation is able to meet the current load requirements. The growth in the region is putting pressure on the reserve capacity that is current available. New power plants have to be built, but financing these projects and environmental issues are delaying the start of the projects.

2.2 Industrial Consumer View

The vastness of the area and the low power consumption density in most African countries makes operation of the interconnection difficult from an operational point. Many of the loads are connected to spurs off a grid that has a low level of interconnectivity. In addition, most of the networks have suffered from a lack of maintenance due to a shortage of funds. This has dramatically reduced the reliability of the system and outages frequently occur in many places.

The combination of these factors has forced industries to provide their own generating facilities in the form of diesel power. These plants then operate in island mode and will often also provide power to towns and villages in the immediate vicinity of the plant.

Some utilities are discouraging this practice, but need to convince these clients to connect to a grid that may not be that reliable in the first place, particularly in areas connected to spurs [3,4].

2.3 Deregulation of the Utility Industry in Southern Africa

Very little true deregulation of the utilities in Southern Africa has taken place. Some attempts are currently being made to deregulate state owned utilities. South Africa and Tanzania are starting to make progress is this regard. In South Africa there are plans to partially privatise the national utility. The generation and distribution sections are being targeted. The transmission system will stay a utility. This will also open the door to medium-sized independent power producers. In Tanzania two independent power producers have been established and the state-owned utility is preparing for unbundling and privatisation.

The deregulation process is difficult to manage. Labour unions in two countries are opposed to the unbundling and privatisation of utility companies. This delays the process and creates uncertainty in the minds of potential investors. The knock-on effect is that less money is being spent by utilities in upgrading system. Utilities therefore depend on loans from the World Bank, the state, and donor countries' funds to expand and upgrade their networks.

Donor countries are providing funds for consultants to analyse the performance, reliability, sustainability and financial systems of utilities. This is helping to get many of the utilities back on their feet by ensuring better financial and technical management.

The situation in the SAPP is steadily improving and a short-term energy market has been established between the various utilities. Key projects are also in the pipeline to improve the generation and transmission capabilities within the SAPP.

3. TOWARDS DEVELOPING A COMPETITIVE MARKET FOR REGIONAL ELECTRICITY CROSS BORDER TRADING: THE CASE OF THE SOUTHERN AFRICAN POWER POOL.

The trading of electrical energy between neighbouring countries is synonymous with economic development and the enhancement of the quality of societal life. Based on intergovernmental agreements, the general arrangement is for national utilities to engage in long term bilateral contracts for the sourcing and consumption of electrical energy. Intergovernmental agreements and the bilateral contracts form the foundation for cross border trading in electrical energy.

Routine activities include scheduling, settlements and the monitoring of quality of supply. Detailed investigations are conducted into inadvertent energy flows and major power system faults and disturbances.

For bi-lateral contracts, the pricing of electrical energy is negotiated and the outcome is generally based on the classical economics of supply and demand. At times of peak consumption, the price for electrical energy is generally higher. At times of off peak consumption, the prices are generally lower. Comparison of the difference in rates for peak and off peak consumption for four countries in the Southern Africa market is given in Table 1.

The off peak tariff in most countries is approximately 40 % of the peak tariff. This difference promotes new business opportunity. Hence, a new process is introduced for the pricing of electrical energy in the short term. The time-based differentiation in pricing arises from the physical constraint in that produced electrical energy must be instantly consumed. Storage of electrical energy is not practical. Energy banking and pumped storage schemes are the exceptions for electrical energy storage for a very small percentage of the total electricity generated.

3.1 Case Study for Southern African Power Pool

Table-1: Difference in Rates for Peak and Off Peak consumption for domestic customers with a monthly average consumption of 450 kWh in four countries in the Southern African Electrical Energy Market.

Country	*Peak to Off Peak Differences in Rates*
South Africa	Peak: 0.034 US c/kWh Off-Peak: 0.014 US c /kWh Difference: 0.020 US c /kWh
Zimbabwe	Peak: 0.051 US c /kWh Off-Peak 0.020 US c /kWh Difference: 0.031 US c /kWh
Botswana	Peak: 0.04 US c /kWh Off-Peak: 0.016 US c /kWh Difference: 0.024 US c /kWh
Namibia	Peak: 0.033 US c /kWh Off-Peak: 0.013 US c /kWh Difference: 0.020 US c /kWh

The Southern African Power Pool (SAPP) is a regional body that was formed in 1995 through a Southern African Development Community (SADC) treaty to optimize use of available energy resources in the region and support one another during emergencies. The power pool's, Co-ordination Centre is located in Harare, and comprises twelve SADC member countries represented by their respective electric power utilities.

SAPP is managed by the decision-making that occurs in the hierarchical structured committees illustrated in Figure 1. Reporting to the Energy Ministers of SADC is the Executive Committee that is composed of the Chief Executives of the participating utilities. Reporting to the Executive is the Management Committee, which is composed of senior managers from the transmission system operations and energy trading divisions of each utility.

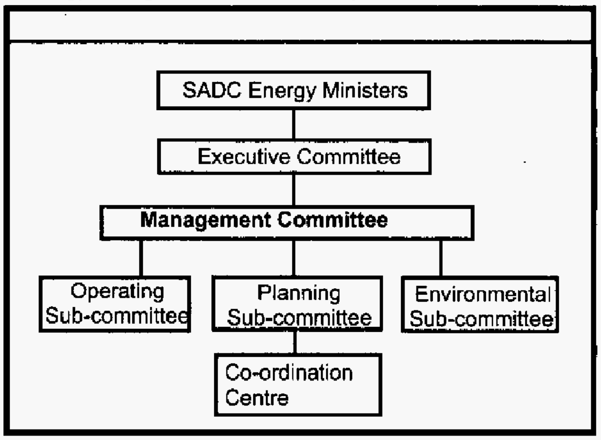

Figure 1. SAPP Structure

The Management Committee collates the proceedings of the sub-committees of Operating, Planning and Environmental, summarizes the proposals and recommendations and presents bi-annually the report to the Executive Committee. In the SAPP proceedings of 1999, the recommendation from the Operating Sub-Committee to introduce a competitive market for short term energy trading was submitted and approved. The design and rules of the short-term energy market is now summarised. The results of more than two years of trading activity have been analysed and are also summarised.

3.2 Design of the Short Term Energy Market

The goal of standard market design is to establish an efficient and robustly competitive wholesale electricity marketplace for the benefit of consumers [5]. This could be done through the development of consistent market mechanisms and efficient price signals for the procurement and reliable transmission of electricity combined with the assurance of fair and open access to the transmission system.

For the Short-Term Energy Market (STEM) design, the following criteria was submitted as input:

i.) ***Transmission rights*** - Long and short-term bilateral contracts between participants have priority over STEM contracts for transmission on the SAPP interconnectors. All the STEM contracts are subject to the transfer constraints as verified by the SAPP Co-ordination Centre.

ii.) ***Security requirements*** - Participants are required to lodge sufficient security with the Co-ordination Centre before trading commences and separate security is required for each energy contract.

iii.) ***Settlement*** - Participants have the full obligation to pay for the energy traded and the associated energy costs. The settlement amounts are based on the invoices and are payable into the Co-ordination Centre's clearing account. It is the responsibility of the Participants (buyers) to ensure that sufficient funds are paid into the clearing account for the Co-ordination Centre to effect payment to the respective Participants (sellers).

iv.) ***Currency of trade*** - The choice of currency is either the United States Dollar or the South Africa Rand dependent on the agreement between the buyer and the seller.

v.) ***Allocation method*** - The allocation of available quantities based on the available transmission capability is by fair competitive bidding with equal sharing of available quantities to the buyers.

vi.) ***Firm contracts*** - Once contracted, the quantities and the prices are firm and fixed. There are currently three energy contracts that have been promoted in the STEM as follows; monthly, weekly and daily contracts.

To commence the design process, three working groups were tasked to detail the parameters for settlements (Treasury Working Group), the parameters for Trading (Trading Working Group) and the parameters of governance (Legal Working Group).

The working groups were comprised of specialists from the participating utilities. The work was conducted over a period of one year.

The results of the working groups are summarized in Table 2.

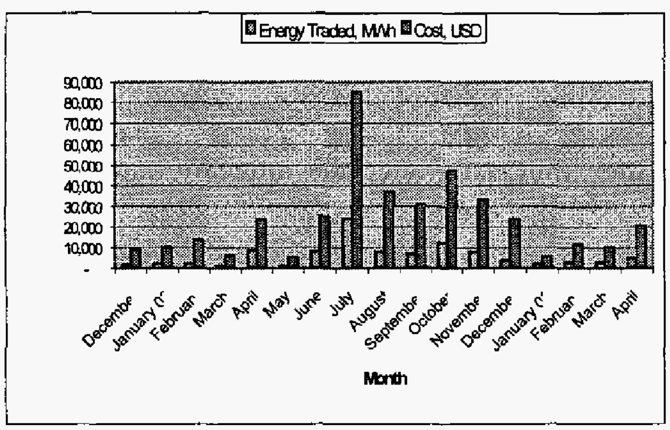

Figure 2. Energy and Volume Traded in Post STEM Energy Market

Table 2. Summary of Design Features for the Short Term Energy Market (STEM).

Treasury Working Group	• Currency of trade. • Security of Payments • Clearing Institution & location • Settlement process
Trading Working Group	• Trading Platform • Wheeling Charges • Trading Rules • Daily Scheduling Procedures • Market Structure
Legal Working Group	• Governance documents • Regulatory Rules • Agreements

The trading platform for the new competitive short-term market was designed locally. The platform employs a matrix for the solution of simultaneous linear equations that were formulated as follows.

3.3 Post STEM Energy Market

The Post STEM energy contracts are concluded outside of the STEM market between participants through bilateral negotiations. Unallocated STEM bids and offers are published on the Internet and these offers and bids are available for hourly trading on the trading day.

This market started in December 2001 and is now about ten percent of the energy traded on the STEM. A higher tariff than the STEM is agreed and trading takes place the next day. Energy and Volume Traded in the Post STEM Energy Market is given in Figure 2

At the 1995 Financial Times World Electricity Conference held in London [6], Professor John Cheshire of the University of Sussex, noted in his Chairman's address that increasing interdependence of regional economies and with improved transmission technology, cross border trading will emerge and provide new opportunities for cost reduction and lower prices to customers. At the same conference, Esser-Scherbeck [6] reported that an open and liberalised German market promoted an increase in competition amongst buyers and sellers and an increase in short term energy trading. The SAPP experience to date concurs with that of Chessire and Esser-Scherbeck.

The outlook for the future regional market includes an increase in trend for deregulation and liberalisation with private equity participation. Spalding-Fecher in contribution to developing South Africa's Energy Policy promotes diversity of source as a strategy to secure national energy supply [7]. Other countries have similar strategies and the net result will be an increase in interconnectivity and cross border trading. The large untapped run of the river projects is now emerging as potential new sources of regional energy; for example the Inga development in the Democratic Republic of Congo. The economic renaissance of the continent gathers momentum, supported by the policies and practices of NEPAD, the New Partnership in Africa's Development.

4. STATUS OF GULF CO-OPERATION COUNCIL (GCC) ELECTRICITY GRID SYSTEM INTERCONNECTION

Recognizing the benefits of interconnection of their power grids, the six Arab states of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) undertook a study in 1990 to define an Interconnection Project and to determine its feasibility. The study recommended an AC interconnection of the 50 Hz systems of Kuwait, Bahrain, Qatar, UAE and Oman with a back-to-back HVDC interconnection to the 60 Hz Saudi Arabian system. The study concluded that the recommended Interconnection Project for the GCC countries was technically feasible as well as economically and financially viable.

The Gulf Co-operation Council Interconnection Authority (GCCIA) has been established and given the mandate to proceed towards implementation of the Interconnection Project as recommended in the 1990 study,

In light of the time that has elapsed since the 1990 study and in view of evolution of the power sectors in the GCC countries, it was decided in 2002 to update the 1990 studies and to re-confirm the feasibility of the Interconnection Project, carry out a Market study, prepare a plan for financing of the Project, develop the Agreements that have to be reached between the different countries, and prepare an implementation strategy.

4.1 Evolution of the Power Sectors in the GCC Countries

In 1990 all the power utilities were government owned and vertically integrated. Governments in the region have already embraced the need and accepted the benefits of private sector participation in the power sector. Since then, legislation has been passed in Oman, U.A.E., Qatar and Saudi Arabia allowing the construction and operation of private power (and desalination) plants. Bahrain is expected to embrace private sector participation in the power sector shortly. Most of the GCC countries are in the process of unbundling their power systems into generation, transmission and distribution entities. The presence of an Interconnection between the GCC countries will, in addition to enabling sharing of reserves, thus reducing the generation requirements in each country, provide the opportunity for trading electricity between the member countries as well as eventually trading outside the GCC.

4.2 Demand Growth in the GCC Countries

The demand in GCC countries as shown in Table 3 is expected to grow from 32,747 MW to almost 94,000 MW over the next 25 years.

Table 3. Demand Growth up to 2028

Year	Kuwait MW	Saudi Arabia* MW	Bahrain MW	Qatar MW.	UAE MW	Oman MW	Total MW
2003	7685	9910	1547	2308	9137	2160	32747
2008	10284	13945	2070	3184	12780	2662	44925
2010	11555	14745	2325	3387	14383	2824	49219
2028	27017	23210	4989	4649	29358	4558	93781

* The Saudi Arabia demand only includes the demand supplied by the SEC-ERB (i.e., the load in the Eastern Region and the firm exports to the Central Region)

4.3 Interconnection Project

The feasibility study recommended that grid system interconnection between the GCC states is feasible from all technical and financial considerations and recommended the project be carried out in three phases..

- Phase I: Interconnection of the Northern Systems (Kuwait, Saudi Arabia, Bahrain and Qatar) in 2008.
- Phase II: The internal interconnection of the Southern Systems (UAE and Oman) to form the UAE National Grid and the Oman Northern Grid.
- Phase III: Interconnection of the Northern and Southern Systems in 2010.

The Interconnection Project is comprised of the following principal elements:

Phase I:

- A double-circuit 400 kV, 50 Hz line from Al Zour (Kuwait) to Ghunan (Saudi Arabia) with an intermediate connection at Fadhili (Saudi Arabia) and associated substations.
- A back-to back HVDC interconnection to the Saudi Arabia 380 kV, 60 Hz, system at Fadhili.
- A double circuit 400 kV connection comprising overhead lines and submarine link from Ghunan to Al Jasra (Bahrain) and associated substations.
- A double circuit 400 kV line from Ghunan to Salwa (Saudi Arabia) and associated substations.
- A double circuit 400 kV line from Salwa to Doha South (Qatar) and associated substations.
- A Control Centre located at Ghunan.

Phase III:

- A double circuit 400 kV line from Salwa to Shuwaihat (UAE) and associated substations.
- A double circuit 220 kV line from Al Ouhah (UAE) to Al Wasset (Oman) and associated substations.
- A single circuit 220 kV line from Al Ouhah (UAE) to Al Wasset (Oman) and associated substations.

The capacity of the Interconnection to each of the countries is given in Table 4.

Table 4. Size of Interconnection to Each GCC State

System	Size (MW)
Kuwait	1200
Saudi Arabia	1200
Bahrain	600
Qatar	750
UAE	900
Oman	400

4.4 Cost of the Interconnection Project

The estimated cost of the Interconnection Project based on economic conditions of 2003 for Phase I and Phase III is $US 1189 million and $US 137 million, respectively.

4.5 Benefits of the Interconnection Project

The principal benefits that can be achieved through Interconnection are as follows:

- Interconnections result in the requirement for lower installed capacity in each of the systems (due to reserve sharing) while still supplying the load with the same (or better) level of reliability.
- Interconnections can permit larger and more efficient generating units to be installed on the individual systems.
- Interconnections enable systems to share operating (spinning) reserves so that each system can carry less spinning reserve.
- Interconnections enable interchange of energy between systems resulting in a lowering of total operating costs.
- Interconnections permit assistance from neighboring systems to cope with unforeseen construction delays and unexpected load growth.
- Interconnections permit emergency assistance between systems to mitigate the effects of unforeseen contingencies such as catastrophic multiple outages.

In the present study the benefits due to reduced generation requirements as a result of reserve sharing were quantified. In addition, the opportunity for power trading between the countries was assessed.

The principal benefits due to the interconnection arise from the sharing of reserves between the systems and the consequential reduction in the installed generating capacity and associated operating and maintenance costs in the GCC countries. The capacity benefits to 2028 for Phase I are shown in Table 5.

Table 5. Generation Capacity Reduction Benefit for Phase 1 Countries

Country	Load (MW)	Total Installed Capacity (MW)		Cumulative Benefit (MW)	Reserve (MW)	
		Isolated	Interconnected		Isolated	Interconnected
Kuwait	27017	30397	29066	1331	3380	2049
Saudi Arabia	23210	26361	24752	1609	3151	1542
Bahrain	4989	5782	5494	288	793	505
Qatar	4649	5427	5060	367	778	411
Total	59865	67967	64372	3595	8102	4507

It was also found that given the high differential between the price of gas and the price of crude oil (a ratio of almost one to four) there is significant potential for economy interchange between the countries. However, there is a lot of uncertainty in whether or not such savings can be counted on towards the economic justification of the Project. Nevertheless, the studies showed that there is an opportunity to trade and for the countries to realize substantial benefits.

4.6 Economic Evaluation

The economic evaluation of the Project showed that the benefit to cost ratio for Phase I of the Project is of the order of 1.5 and that the pay back period for the investment is less than four years. Given the small incremental cost of Phase III it is evident that implementation of Phase III would further improve the attractiveness of the Project. Thus the analysis has re-confirmed the economic viability of the Project.

4.7 Sharing of the Costs of the Interconnection Project

It was agreed amongst the countries to share the costs of the Interconnection in proportion to the reserve capacity savings. Considering the time value of money and that the capacity savings occur at different points of time, it was agreed to share the costs in proportion to the present value of the capacity savings.

4.8 Financing Options for the Project

The financial analysis has re-confirmed the financial feasibility of the Project.

The various options of financing the total cost (capital and operational) of the project are being considered in detail in a separate study carried out by the Gulf Investment Corporation (GIC). The finance of the project can be partially or wholly provided from loans or with participation by the private sector, with or without contribution by the governments.

The options of financing the project which was considered in the 1997 feasibility studies were five options as given in Table 6. The first and second option is based on full (100%) ownership of the project by the government, in which case the governments will be responsible for all costs associated with the project.

The third option considers full ownership by the private sector. The last two options considers joint ownership with different percentage participation and ownership between governments and the private sector.

Table 6. Financing Options Considered

Finance Options	Ownership		*Sources of Finance*		
			Capital		
	Govern-ment	Private sector	Govern-ment	Private sector	Loans
1	100 %	-	100 %	-	-
2	100 %	-	35 %	-	65 %
3	-	100 %	-	35 %	65 %
4	50%	50%	17.5 %	17.5 %	65 %
5	50%	50%	25 %	25 %	50 %

There were various important issues when considering the finance options for the project:

- Government risks
- Enhanced efficiency of the private sector to carry out the project when compared to the government
- Cost of provision of finance by the government

The GCCIA was set up as per the second option in which the government will be responsible to take 35 % of the cost of the project with the remaining 65 % provided from loans.

4.9 Next Steps

An implementation strategy is being developed. Relevant agreements are being drafted to confirm the commitment of each of the countries to the Project. An information memorandum is being prepared to solicit financing for the Project.

In summary, the present studies have re-confirmed the technical feasibility and the economic and financial viability of the Project.

Steps are now being made to take the Project to market and to work towards its implementation.

5. STATUS OF INTERNATIONAL INTERCONNECTIONS IN NORTH AFRICA

Interconnections between neighbouring utilities are becoming increasingly vital for the implementation of an open energy trading market and to increase the reliability of power systems. The power utilities of the Arab countries in North Africa and the Middle East have made considerable investments in extending transmission system interconnections and power-transfer corridors at various voltage levels to facilitate cross-border trading of electric power.

5.1 North African Interconnectors

Libya is a large country that shares borders with six neighbouring countries, four Arab states (Egypt, Sudan, Algeria and Tunisia) and two African states (Chad and Niger). Currently Libya is only electrically interconnected with Egypt at the east network boundary where energy has been exchanged through the tie line since the circuit was commissioned summer 1999. This interconnector was constructed as a double-circuit 220-kV line connecting Tobruk substation in Libya, approximately 150 km inside the border, with Salum Substation in western Egypt. The 220-kV transmission line extends 165 km and is capable for commercial trading of 200 MW in either direction. This line extends across the Egyptian desert another 350 km before it reaches areas of dense energy consumption and the load centers of the Mediterranean city of Alexandria. The overall length of the transmission line is 500 km.

The power system of the Egyptian Electricity Authority (EEA) is interconnected on the eastern boundary of the country with the Jordanian system through a 500-kV circuit that links the two countries via overhead lines and a submarine cable crossing under the Bay of Aqaba in the Red Sea. Jordan is electrically interconnected with Syria, whereas Syria is about to be linked with the eastern boundary of the European grid (UCTE) via Turkey.

Tunisia and Algeria border Libya's western boundary, but until now, there has been no power-system interconnections between these two countries. However, the Tunisian and Algerian power grids are interconnected with two links, and Algeria is interconnected at its western border with Morocco, which is connected with Western Europe via Spain.

The 400-kV AC link with Spain, comprising transmission lines and a submarine cable under the Straits of Gibraltar, connects Mellousa Substation in Morocco with Pinar del Rey Substation in Spain. The "missing link" is the Libya-Tunisia interconnection, which will close the loop of the Mediterranean Basin countries when commissioned.

5.2 Jordan -Egypt Red Sea Interconnection

The development includes a 400-kV submarine cable that crosses the Gulf of Aqaba between Taba in Sinai and Aqaba in Jordan. This link, which is an important stage in the planned interconnection between Egypt, Jordan, Syria, Iraq and Turkey, will be the first electrical connection between Asia and Africa and will eventually lead to a grid loop extending all the way around the Mediterranean. Commissioning of this circuit was in 1997.

More specifically the situation is:

- Tunisia-Libya: two lines at 220 kV (1 single circuit and 1 double circuit) have been completed. Permanent synchronisation between the two blocs is subject to outcome of the testing phase that is envisaged will be completed in 2004;
- Syria-Turkey: a 400 kV line (Birecik-Aleppo) is now completed, but its exploitation will probably not take place prior to connection of the Turkish system to UCTE;
- Turkey-UCTE: Turkey is presently interconnected with Bulgaria through two 400 kV lines.

5.3 Other Developments: North-South HVDC Connections

To enhance the possibility of electricity trading between Southeast Mediterranean countries (SEMC) and Europe, some South-North HVDC links are under study. The corridors under investigation are:

- Algeria-Spain: the feasibility study for a HVDC connection from Terga to Litoral de Almeria through a submarine cable (connection about 240 km) with a capacity of 2000 MW has been completed. The construction of 2000 MW of new generation (possibly CCGT) in Algeria – out of which 800 MW for local needs and 1200 MW for export - has been planned. Because of the difficulty in getting foreign investments, the project will be commissioned in two stages. At the beginning a bipolar HVDC link rated 1000 MW will be realised with marine electrodes for emergency current return;
- Algeria-Italy: the project of a potential interconnection rated 1000 MW between Algeria and Sardinia (Italy) is at a pre-feasibility stage. This project will be integrated with a second HVDC link, developed in two modules (500MW+500MW), between Sardinia and Continental Italy.

Further envisaged HVDC links are relevant to Tunisia-Italy (2000 MW) and Libya-Italy (600~1000 MW). For these latter projects no detailed feasibility analyses have been carried out so far.

5.4 Future Perspectives

Looking into the future, further steps are envisaged related to the extension of the Euro-Mediterranean synchronously interconnected system, namely:

- Extension to South: synchronous interconnection between Egypt and Sudan (220 kV line);
- Extension in the Middle East with the interconnections Syria-Iraq (400 kV line), Turkey-Iraq (400 kV line) and Jordan-Western part of Saudi Arabia (voltage level to be defined).

The Red Sea Cable Interconnection Project linking the electrical networks of Egypt and Jordan will operate with an initial interchangeable energy of 300 MW rising to 2000 MW at a future stage.

6. IMPACT OF PRIVATIZATION AND DEREGULATION ON INFRASTRUCTURE DEVELOPMENT IN AFRICA

In an effort to reduce poverty and accelerate growth, developing economies have been urged to deregulate and privatize sectors, such as the energy sector. This requires significant investment in infrastructure. The World Bank has been promoting these strategies and, through the International Finance Corporation (IFC), providing low interest loans to finance joint public/private projects to develop infrastructure on a Build-Own-Operate-Transfer (BOOT) basis. Under this scheme the government or local utility becomes the owner of the plant after the private investors have recovered their original investment over a number of years (typically 15-30 years).

6.1 Project Financing and Investment

Traditionally, governments have publicly financed infrastructure projects in many developed and most developing regions. In the energy sector, this was achieved through a national or regional, vertically integrated utility. There has been a move over the past decade to encourage private participation in infrastructure investments. Large infrastructure projects are now organized under complex ownership and financial structures designed to appropriately spread risks, assign costs and allocate benefits.

6.2 Public Private Partnership (PPP) Project Structures

The major dimensions under which PPP projects are structured are ownership (public, private, foreign, local), and financial structure (equity, debt and grants) [8].

The traditional public ownership of infrastructure projects is being eschewed in favour of private participation. Private ownership can be either through a joint venture with the government (or the local utility) or for a period of time after which ownership is transferred to the utility. In the second approach, the private investor builds, owns and operates the plant for fixed a period after which the plant is transferred to the utility. This is now the more popular approach since the private investor has full control during the building and initial management and operations of the plant. This gives the utility staff time to develop and acquire the necessary expertise to take over the running of the plant. Since local capital is usually unavailable to support infrastructure projects, private participation is usually through foreign direct investment. In order to encourage local participation and local capital formation, some governments may require a certain level of local private participation.

Infrastructure projects are typically financed using a combination of equity and debt financing. Since equity financing is via risk capital, only the more risky but viable projects will attract such investments.

6.3 Project Negotiations

One problem with PPPs is that less developed countries in Africa are not a in a position to negotiate favourable contracts with large foreign firms whose annual sales may exceed their GDP. Foreign firms not only negotiate from a position of strength but also tend to overestimate the risk involved with these types of projects [9]. They therefore impose onerous contractual terms and require very high rates of return that, in the case of electricity, results in very high take or pay tariffs that the government or local utility has to impose on the local population. Furthermore, the resulting projects tend to have high capital costs and expenses based on western wage rates and expenses.

6.4 The California Experience

The well-documented energy crisis in California [10] at the turn of the 21st century illustrates the problems that can befall even a sophisticated economy when liberalization of the energy sector is carried out too quickly and without ensuring that appropriate safeguards are in place. While many reasons contributed to the energy crisis, the three areas in which developing countries can draw useful lessons are in 1) the low level of infrastructure built during the 1990s, 2) the structure and types of contracts the utilities were allowed to sign, and 3) the speed with which the energy industry was deregulated.

6.5 The Bujagali Hydroelectric Project in Uganda

Bujagali is a 200 MW hydropower dam project on the Victoria Nile in Uganda. One of the largest private power projects in Sub-Saharan Africa, and the largest private investment in East Africa, it is being developed as a public private partnership BOOT project supported by a 30 year PPA. The private investors were originally led by the US-based AES Corporation, one the world's largest private power producer, until they pulled out of the project in August 2003. The project is supported by the World Bank and the IFC provided debt financing to the Ugandan government for its portion of the project. Project costs are estimated at $580 million with an 80/20 debt/equity ratio.

In an analysis of the PPA [11], it is concluded that the project was about twice as expensive as a comparable hydro project. The complex PPA had the Ugandan government bearing most of the risks of adverse foreign exchange movements, operational risks during dry years and the financial risks if interest rates rose.

The project was negotiated with a single consortium of private investors and no competitive process was used to strengthen the negotiating position of the government and ensure that the lowest cost is obtained. Since size of the project is large, the capacity of the Ugandan government to engage in other power projects is limited and in fact, the PPA explicitly prohibits the government from entering into other contracts until the project achieves financial closure.

6.6 The Effect of Globalization

Developing economies in Africa currently have little choice but to participate in the dominant global approaches now being promulgated by international agencies. However, the lack of the ability to negotiate international trade and investment agreements effectively results in projects where the government bears a disproportionate amount of risk and pays a very high price for the invested capital [12]. This problem will have to be addressed by governments finding, nurturing and engaging reliable partners. For-profit global power companies are unlikely to be suitable for such roles since they are beholden to their shareholders to show returns on investment commensurate with the risk of an infrastructure project.

Suitable partners will have to be knowledgeable and skilled and they have to be aligned with the objectives of the government. A similar model has worked well to date for the technical consulting and advise that governments have sought during the planning phase of projects

In the drive to accelerate development, reduce poverty and replicate the success of Asian economies, the current approach to developing infrastructure in Africa through market liberalization and public/private partnerships holds significant risks for its developing economies. The difficulty in negotiating fair contracts that balances risks raises questions about the desirability of these very large projects whose risk may be unacceptable. A more acceptable approach could be to focus on a portfolio of many smaller projects. The economy would then be less susceptible to impact of a delay or failure of any one project.

It is recommended that government establish and train a cadre of legal, financial and technical experts to negotiate contracts. All contracts must be by competitive tender. In order to minimize the risk of unintended consequences, PPAs and similar contracts should be kept as simple as possible and standardized whenever possible.

Debt financing of least cost planned expansions should be used whenever possible. This will provide governments with better control over their energy destiny. Equity investments should be reserved only for the highest risk projects.

7. REFERENCES

[1] Southern African Power Pool, Annual Report 2001/2, Southern African Power Pool, 2002.

[2] G. Chown and M. Coker, Interirm report on frequency relaxation, Southern African Power Pool, August 2000.

[3] D. Louw and N. Uhlarz, NETGroup Solutions - on Tanesco, Traders African Business Journal, Issue 15, Aug to Nov 2003, pp68-70.

[4] A. Tassell, Tanesco on the road to recovery, African Energy Journal, May / June 2003, vol 5, no 3, pp6-9.

[5]. Principles on Standard Market Design. Edison Electric Institute. July 2002.

[6[. Financial Times Conferences, 1995. World Electricity Conference: London (UK), Pearson Professional Publication, London, UK.

[7]. Spalding-Fecher, R., 2002. Energy and Energy Policies in South Africa: An Overview. NER Quarterly Journal. Issue 1,2002,p 1-18.

[8]. Fouzul Khan, Robert Parra, "Financing Large Projects: Using Project Finance Techniques and Practices", Pearson Education Asia Pte., Ltd.; March 2003.

[9]. MARC H. GOEDHART AND PETER HADEN, "Over-measuring Risk in Emerging Markets" *The McKinsey Quarterly, 2003 Number 4 Global directions.*

[10].James L. Sweeney, "The California Electricity Crisis", Hoover Institution Press Publication, July 2002

[11] Prayas Energy Group, "The Bujagali Power Purchase Agreement – an Independent Review" for International Rivers Network.

[12].Joseph Stiglitz, "Globalisation and its Discontents", published by W.W. Norton & Company, April 2003

8. ACKNOWLEDGEMENT

The author acknowledges contributions made by Pat Naidoo (Senior General Manager of Transmission, Eskom, South Africa); I Musaba, W. Ballet, and A. Chicova, (Harare, Zimbabwe), A. Majeed H A Karim (Secretary to the Board of Directors, GCC Interconnection Authority (GCCIA), Kingdom of Saudi Arabia); Jan A de Kock (Potchefstroom University, South Africa), F. T. Sparrow, (Power Pool Development Group, Purdue University, USA), Wei-Jen Lee (Director, Energy Systems Research Center, University of Texas at Arlington, USA), B.K.Blyden (BBRM Investments, CA, USA), James Momoh (Director, National Science Foundation, VA, USA), Ahmed Faheem Zobaa (Cairo University, Egypt), Lori Pottinger (International Rivers Network, USA), Moshin Chen, (Professor Emeritus, University of Texas at Arlington, USA), and Raymond Johnson (Engineering Consultant, BBRM Investments, CA, USA)..

Contact Author: T. J. Hammons, Glasgow University, 11C Winton Drive, Glasgow G12 0PZ, UK, E-mail: T.Hammons@ieee.org