Intereconnection of electric power systems of regions, states and individual territories is acquiring a growing scale of importance in world practice. Key to this is a 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 economic, ecological and technological efficiencies of the joint operation of electric power systems. The effort to limit greenhouse gas (GHG) emission is one such major benefit. Another important benefit with institutionwide implications is the modeling of these initiatives.

Africa and the Middle East are favourable regions for electric power grid creation based on the above system effects, on account of the different levels of economic development in the different countries of the region, the different placement of fuel resources, energy resources and consumers, etc. Therefore, an understanding of the present status and future trends ofAfican and Middle Eastern electricity interconnections is important in efforts to improve efficiency, limit GHG emissions and bridge the digital divide.

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 in accommodating the varying demand profiles and 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.

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 countries are in one way or another dependant on South Africa for supplying the balance of their power consumed and in stabilising their grid network. This is achieved by co-operation within the Southern African Power Pool (SAPP). SAPP consists of representatives of the state-owned utilities of Botswana, Democratic Republic of the Congo (DRC), Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zimbabwe, and Zambia, whose systems 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 being 41.3 GW.

Typically, South Africa’s neighbors produce most of their own power. South Africa produced 8.6% of their consumed energy in 2001/2 [2].

Power system stability

The SAPP main grid is stable and the frequency control is good [3]. This applies to the main grid connections. However, the level of interconnectivity in countries 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 capacity is able to meet the current load requirements. However, growth in the region is putting pressure on the reserve capacity that is currently available. New power plants have to be built, but financing these projects and environmental issues are delaying the start of the projects.

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 of view. 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 occur frequently in many places.

The combination of these factors has forced some 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 they need to convince clients to connect to a grid that may not be that reliable in the first place, particularly in areas connected to spurs [4, 5].

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 in this regard. In South Africa there are plans to partially privatize 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 privatization.

The deregulation process is difficult to manage. Labour unions in the two countries are opposed to the unbundling and privatization 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 their systems. 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

This paper reviews the present status and future prospects of international interconnections, infrastructure, electricity exchanges and deregulation in Africa from the viewpoint of generation and transmission development, deregulation trends and policies. Part 1 considers the case of the Southern Africa Power Pool (SAPP) interconnections in developing a competitive market for regional electricity cross border trading, while Part 2 (to be published in a subsequent issue of ENERGIZE) considers the Gulf Co-operation Council (GCC) Electricity Grid System interconnections. It is an update and follow-up to a paper on African Electricity Infrastructure, Interconnections and Electricity Exchanges that was published in 2000 [1].
Table 1: Difference of rates for peak and off peak consumption for four countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Peak to Off Peak Differences in Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Peak: 0,034 US $/kWh, Off-Peak: 0,014 US $/kWh, Difference: 0,020 US $/kWh</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Peak: 0,051 US $/kWh, Off-Peak: 0,020 US $/kWh, Difference: 0,031 US $/kWh</td>
</tr>
<tr>
<td>Botswana</td>
<td>Peak: 0,061 US $/kWh, Off-Peak: 0,016 US $/kWh, Difference: 0,045 US $/kWh</td>
</tr>
<tr>
<td>Namibia</td>
<td>Peak: 0,033 US $/kWh, Off-Peak: 0,013 US $/kWh, Difference: 0,020 US $/kWh</td>
</tr>
</tbody>
</table>

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 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 that produced electrical energy must be instantly consumed because storage of electrical energy is not practical. Energy banking and pumped storage schemes are the exceptions for electrical energy storage for a small percentage of the total electricity generated.

### Case study of the Southern African Power Pool (SAPP)

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 the SAPP comprises twelve SADC member countries represented by their respective electric power utilities.

SAPP is managed by the decision-making that occurs in the hierarchically structured committees illustrated in Fig. 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 comprises of senior managers from the transmission system operations and energy trading divisions of each utility.

The Management Committee collates the proceedings of the Operating, Planning and Environmental Sub-Committees, summarizes the proposals and recommendations, and presents the report to the Executive Committee bi-annually. 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 (STEM) is now summarized. The results of more than two years of trading activity have been analyzed and are also summarized.

### 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 [6]. 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 were submitted as input:

- Transmission rights - Long and short-term bilateral contracts between participants have priority over STEM contracts. All the STEM contracts are subject to the transfer constraints as verified by the SAPP Co-ordination Centre.
- 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.
- 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).
- 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.
- 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.
- 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 trading platform for the new competitive short-term market was designed locally. The platform employs a matrix for the solution of a set of simultaneous linear equations.

**Post STEM energy market**

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 10% of the energy traded on the STEM. A higher tariff than the STEM is agreed, and trading takes place the next day. The energy and volume traded in the post STEM Energy Market is given in Fig. 2. The working groups comprise specialists from the participating utilities. The work was conducted over a period of one year.

The design features for the short term energy market are summarized in Table 2.

**Future outlook**

The outlook for the future regional market includes an increase in the trend towards deregulation and liberalization 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 are 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 is gathering momentum, supported by the policies and practices of NEPAD, the New Partnership in Africa’s Development.

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Fig. 2: Energy and volume traded in post STEM Energy Market